

FRAGMENTATION FUNCTIONS FOR THE EIC: KAON FRAGMENTATION REVISITED

Rodolfo Sassot
Universidad de Buenos Aires

**Synergies of pp and pA Collisions with an
Electron-Ion Collider**

RIKEN BNL Research Center Workshop
June 26-28, 2017 at Brookhaven National Laboratory



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DSS07 update:

in collaboration with D. de Florian, M. Epele, R. Hernandez-Pinto, M. Stratmann

Phys. Rev. D 95, 094019 (2017)

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Several relevant new data sets since DSS07

Belle, BaBar, Compass, Hermes, Star, Alice

PHYSICAL REVIEW D **75**, 114010 (2007)
Global analysis of fragmentation functions for pions and kaons and their uncertainties
Daniel de Florian^{*} and Rodolfo Sassot[†]
Departamento de Física, Universidad de Buenos Aires, Ciudad Universitaria, Pabellón 1 (1428) Buenos Aires, Argentina
Marco Stratmann[‡]
Radiation Laboratory, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan
(Received 23 March 2007; published 22 June 2007)

We present new sets of pion and kaon fragmentation functions obtained in next-to-leading order combined analyses of single-inclusive lepton-proton scattering with either pions or kaons identified in the final state. At variance with all previous fits, the present analyses take into account data where hadrons of different electrical charge are identified, which allow one to discriminate quark from antiquark fragmentation functions with all data analyzed, which cover a much wider kinematical range than in previous fits. A agreement with all data analyzed, which cover a much wider kinematical range than in previous fits. A extensive use of the Lagrange multiplier technique is made in order to assess the uncertainties in the extraction of the fragmentation functions and the synergy from the complementary data sets in our global analysis.

DOI: [10.1103/PhysRevD.75.114010](https://doi.org/10.1103/PhysRevD.75.114010)

I. INTRODUCTION AND MOTIVATION

The hadronization process turns partons produced in hard-scattering reactions into the physical, colorless, non-perturbative hadronic bound states detected in experiments. Within the standard framework of leading-twist collinear QCD [1], processes with an observed hadron in the final state can be described in terms of perturbative hard-scattering cross sections and certain non-perturbative but universal functions: parton distributions, accounting for the partonic structure of the hadrons in the initial state just before the interaction, and fragmentation functions, encoding the details of the subsequent hadronization process [2].

These three ingredients are therefore the pillars of the perturbative QCD (pQCD) description of hard interactions; their precise knowledge has been crucial for its success in the past, and is imperative for the ongoing and future high energy research programs [3]. In the past few years, the improvement in each of these key areas has been remarkable. Higher order QCD calculations have been explored and validated for most processes up to next-to-leading order (NLO) accuracy, and are currently being extended even beyond that point for some observables [4]. The knowledge on parton distributions has become increasingly precise as a result of two decades of a wide variety of high precision measurements, and strenuous efforts to update and enlarge periodically the corresponding QCD analyses [5,6]. State-of-the-art sets of parton densities agree with each other well within the already fairly small estimated uncertainties, and provide a picture

of the proton structure fully consistent with most observables, and specifically for the present analysis, the differences between one or another modern set of parton distributions are small compared with the uncertainty of the fragmentation functions. Also fragmentation functions, following the path of parton distribution functions, have not yet attained the precision required for the information used to discriminate between charged hadrons. These deficiencies are of being very precise measurements from CERN experiments, clean, in the sense that they have no dependence on the initial state.

In spite of these advantages, the fragmentation data suffer from several drawbacks: the data give *per se* only the charge sum of the quark from antiquark fragmentation into hadrons, π^- . The information is lost in the "fragmenting" technique, which is implemented in the bulk of the electroweak data. Only flavor-tagged data can provide information on the fragmentation of quarks and antiquarks into hadrons. Also, the fragmentation functions are constrained by the electron-positron annihilation data, which provide a picture of the fragmentation of quarks and antiquarks into hadrons.

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Several relevant new data sets since DSS07

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Pion FFs update DSS14

arXiv:1410.6027

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PHYSICAL REVIEW D **91**, 014035 (2015)
Parton-to-pion fragmentation reloaded
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72076 Tübingen, Germany
(Received 24 October 2014; published 29 January 2015)

We present a new, comprehensive global analysis of parton-to-pion fragmentation functions at leading-order accuracy in QCD. The obtained results are based on the latest experimental information on single-inclusive pion production in electron-positron annihilation, lepton-nucleon deep-inelastic and proton-proton collisions. An excellent description of all data sets is achieved, and the uncertainties in parton-to-pion fragmentation functions are estimated based on the Hessian method. Extensive comparisons to the results from our previous global analysis are performed.

DOI: [10.1103/PhysRevD.91.014035](https://doi.org/10.1103/PhysRevD.91.014035)

I. INTRODUCTION AND MOTIVATION

The quantitative description of hard-scattering processes involving identified light hadrons in the final state requires a precise knowledge of how quarks and gluons hadronize. In the framework of perturbative QCD (pQCD), which we pursue in the following, this vital information is encoded in parton-to-hadron fragmentation functions (FFs) [1]. To match the increasing amount and precision of experimental results, the availability of reliable sets of FFs for a large variety of hadrons, in particular, for neutral and charged pions and kaons, as well as accurate estimates of their uncertainties is of the utmost relevance and the subject of this study.

Like parton distribution functions (PDFs), FFs are required in a pQCD calculation to consistently absorb the effects of collinear parton-parton configurations in distance physics, i.e., interactions happen at short distances. The actual hard-scattering process, however, is a non-perturbative quantity, and any information about them is preferably in a global QCD analysis. FFs are obtained in a large variety of ways, but the most reliable are facilitated by assuming a factorization theorem, one to compute the relevant matrix elements perturbatively. The scale evolution of FFs is predicted by the DGLAP equations, in a way as for PDFs. For a parton of flavor i with four-momentum t at scale Q at which the process takes place, the FF is denoted by $D_i^H(z, Q^2)$. All the analysis of FFs is done at the next-to-leading order (NLO) and the kernels of the evolution equations are single-inclusive annihilation and production cross sections [8], and inelastic and elastic cross sections. A first-order approximation to the FFs is given by the parton model, which is valid at low Q^2 and for small z .

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Several relevant new data sets since DSS07

Belle, BaBar, Compass, Hermes, Star, Alice

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Kaon FFs update DSS17

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We revisit the global QCD analysis of parton-to-kaon fragmentation functions at next-to-leading order accuracy using the latest experimental information on single-inclusive kaon production in electron-positron annihilation, lepton-nucleon deep-inelastic scattering, and proton-proton collisions. An extraction of all data sets is achieved, and the remaining uncertainties in parton-to-kaon fragmentation functions are estimated and discussed based on the Hessian method. Extensive comparisons to the previous global analysis are made.
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Parton-to-hadron fragmentation functions (FFs) parameterize how quarks and gluons that are produced in hard scattering at high energies confine themselves into hadrons and are identified in experiment [1]. This is a non-perturbative quantum chromodynamics (QCD) phenomenon that must therefore be inferred from experimental data. Hadron production cross sections must therefore be inferred from experimental data. Precise parton-to-kaon FFs are a key ingredient to probe the structure of the nucleon and are expected to further constrain the parton distribution functions at a future electron-positron collider. Charged kaon production in deep-inelastic scattering (SIDIS) is helicity dependent [5,6], largely due to the experimental constraints on the weak deep-inelastic scattering cross sections.

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Parton-to-hadron fragmentation functions (FFs) parameterize how quarks and gluons that are produced in hard scattering at high energies confine themselves into hadrons and identified in experiment [1]. This is a non-perturbative property of the hadron production process, and must therefore be inferred from experimental data. Precise parton-to-kaon FFs are a key ingredient to probe the structure of the nucleon and are expected to further constrain the parton distribution functions at a future charged kaon production experiment (SIDIS) [2]. The helicity dependent fragmentation functions $\Delta\bar{d}$ [5,6], largely unknown, are relevant for the study of the weak deep-inelastic scattering.

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Parton-to-hadron fragmentation functions (FFs) parameterize how quarks and gluons that are produced in hard scattering at high energies confine themselves into hadrons and are identified in experiment [1]. This is a non-perturbative quantum chromodynamics (QCD) phenomenon that must therefore be inferred from experimental data. The relevant non-perturbative information is contained in the fragmentation functions (FFs) which are key ingredients to predict the production of hadrons in hard scattering processes. Precise parton-to-kaon FFs are a key ingredient to probe the structure of the nucleon and are expected to be further constrained by future experiments. Contributions at a future charged kaon production experiment (SIDIS) to the helicity dependent parton distribution functions $\Delta\bar{s}$ [5,6], largely determined by experimental constraints, are weak deep-inelastic scattering (DIS) data.

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We revisit the global QCD analysis of parton-to-kaon fragmentation functions at next-to-leading order accuracy using the latest experimental information on single-inclusive kaon production in electron-positron annihilation, lepton-nucleon deep-inelastic scattering, and proton-proton collisions. An extraction of all data sets is achieved, and the remaining uncertainties in parton-to-kaon fragmentation functions are estimated and discussed based on the Hessian method. Extensive comparisons to the previous global analysis are made.
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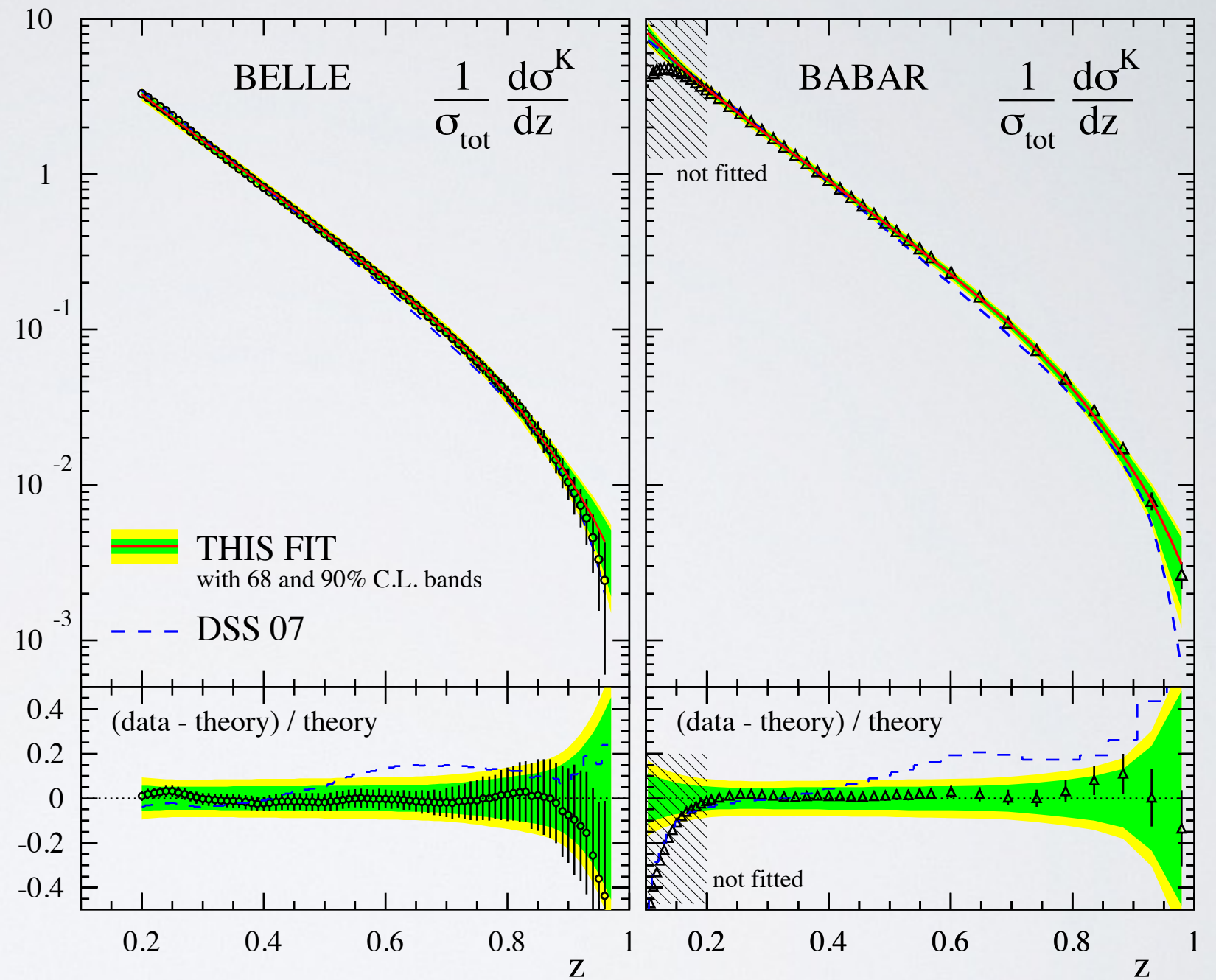
MMHT14 input PDFs and alpha_s

differences with CT14 and NNPDF3.0, not negligible

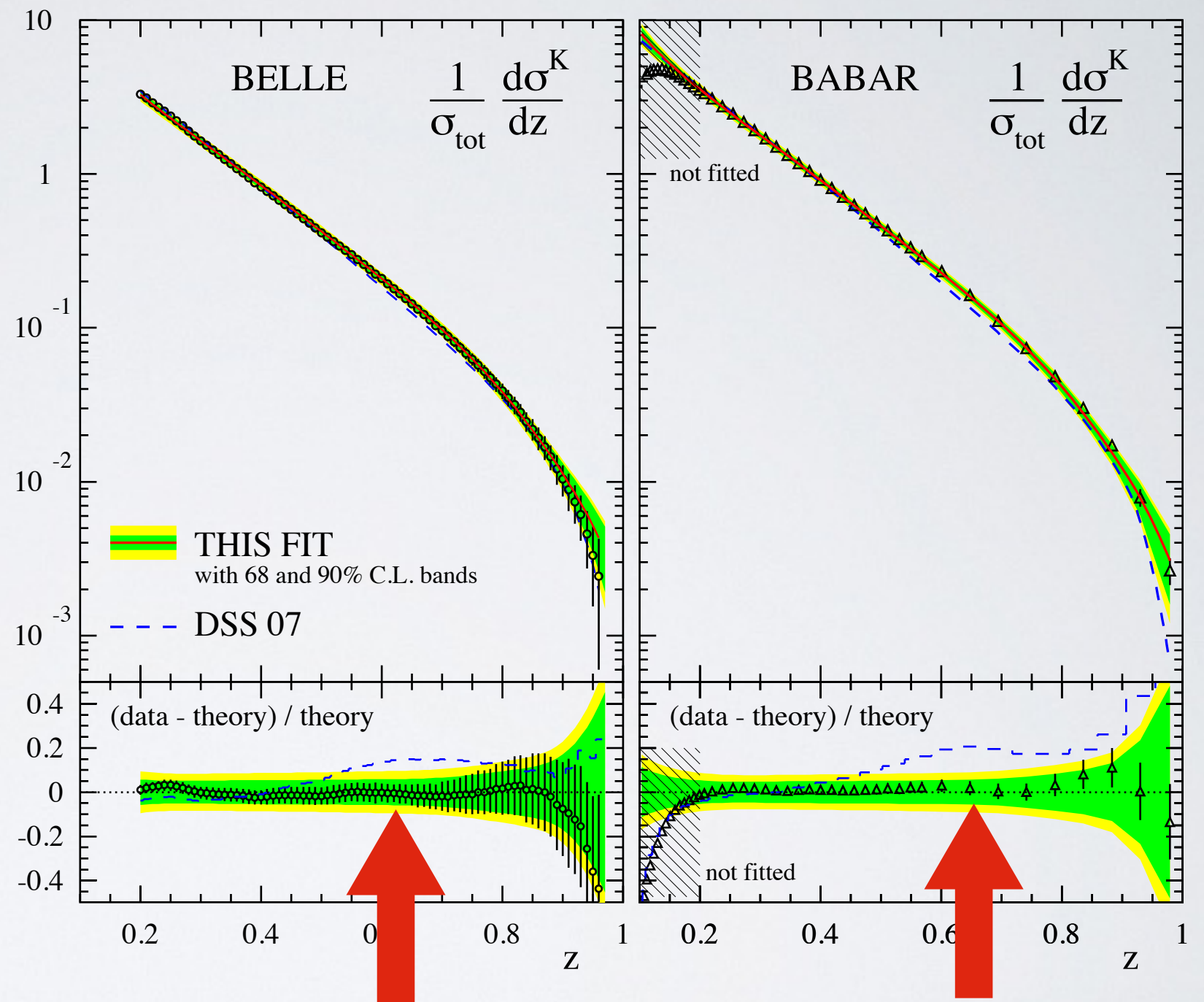
p_T cuts in pp data

68 and 90 % CL error estimates (improved hessian)

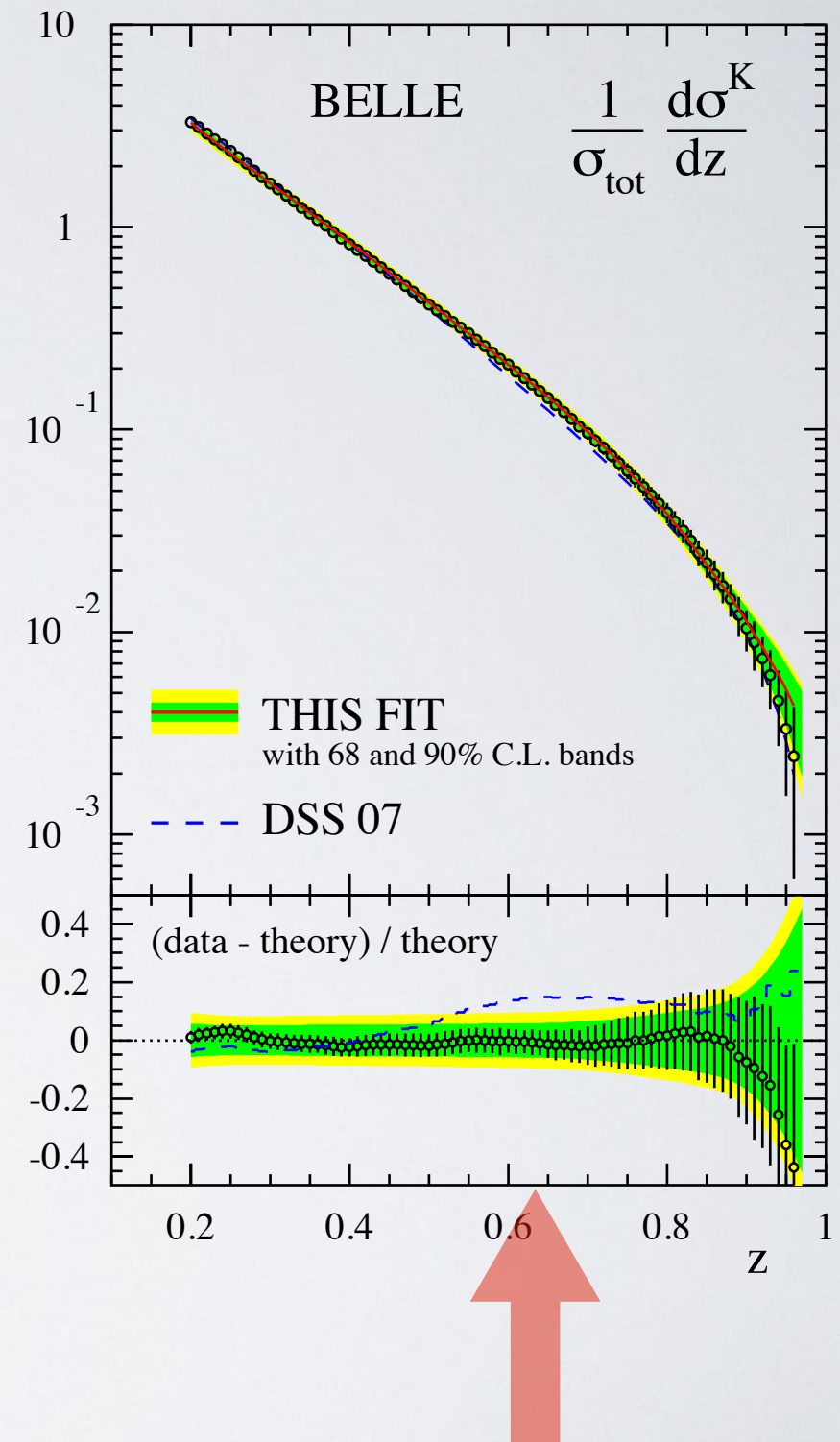
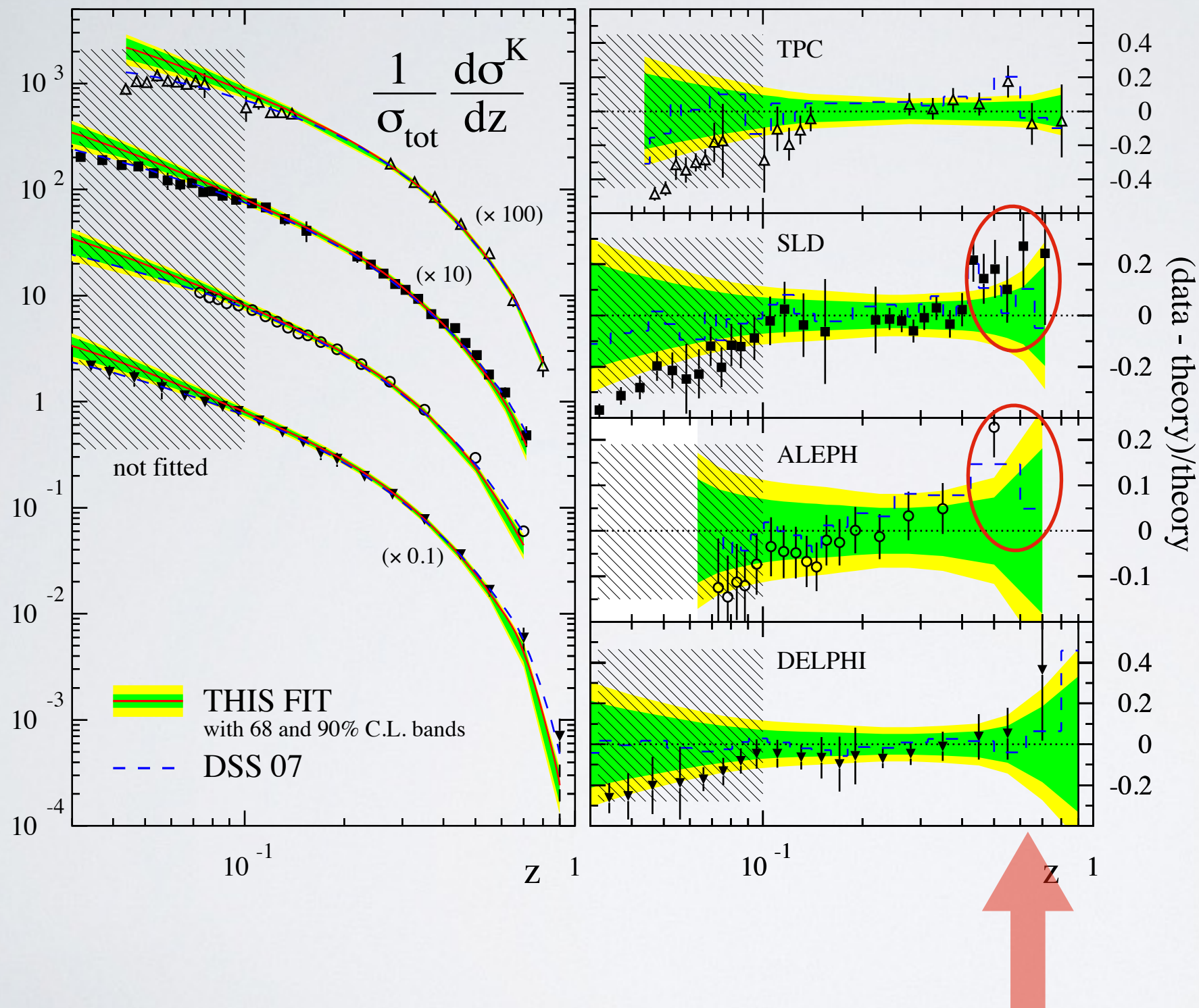
SLA: light quark singlet, charm and bottom



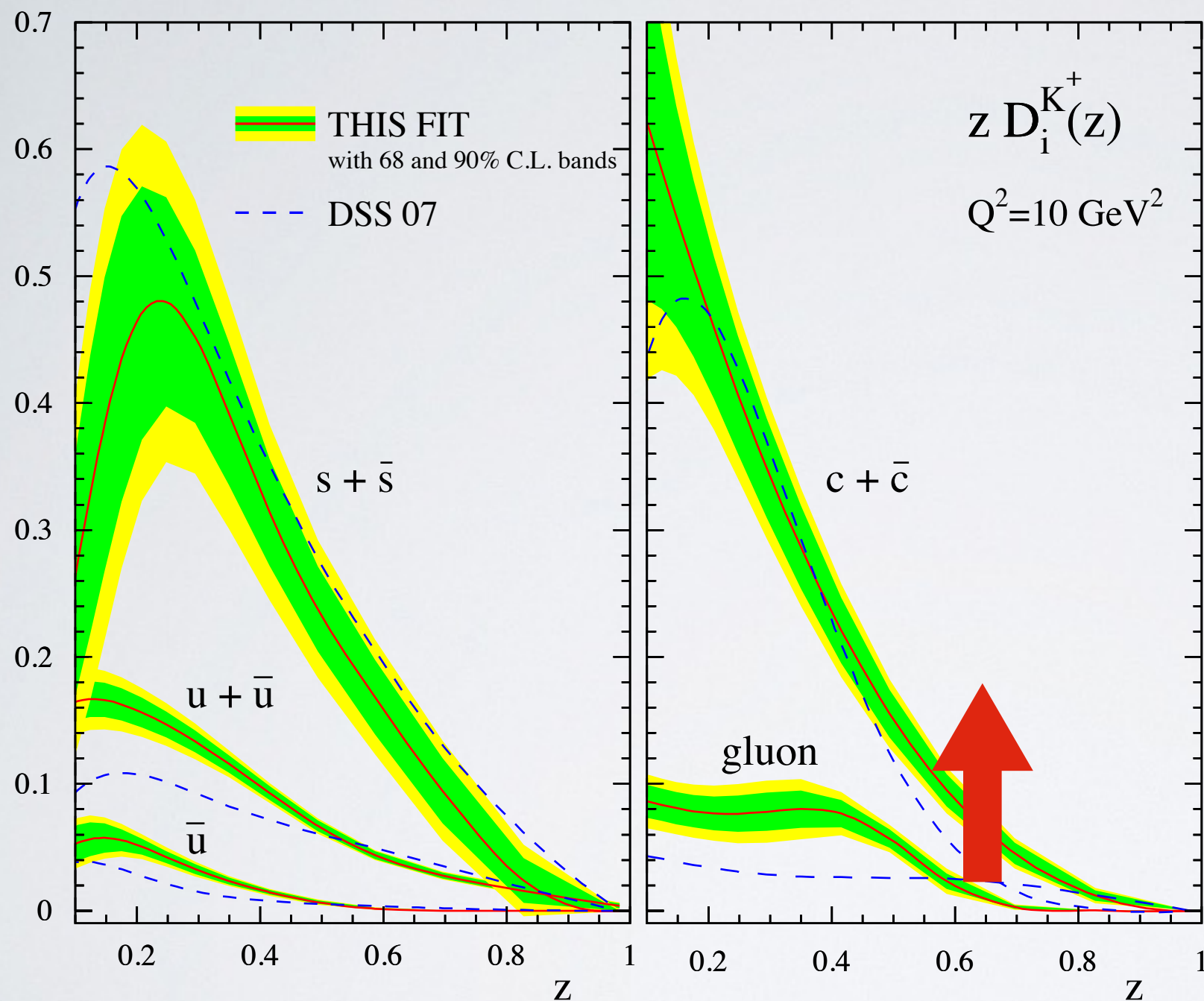
SLA: light quark singlet, charm and bottom



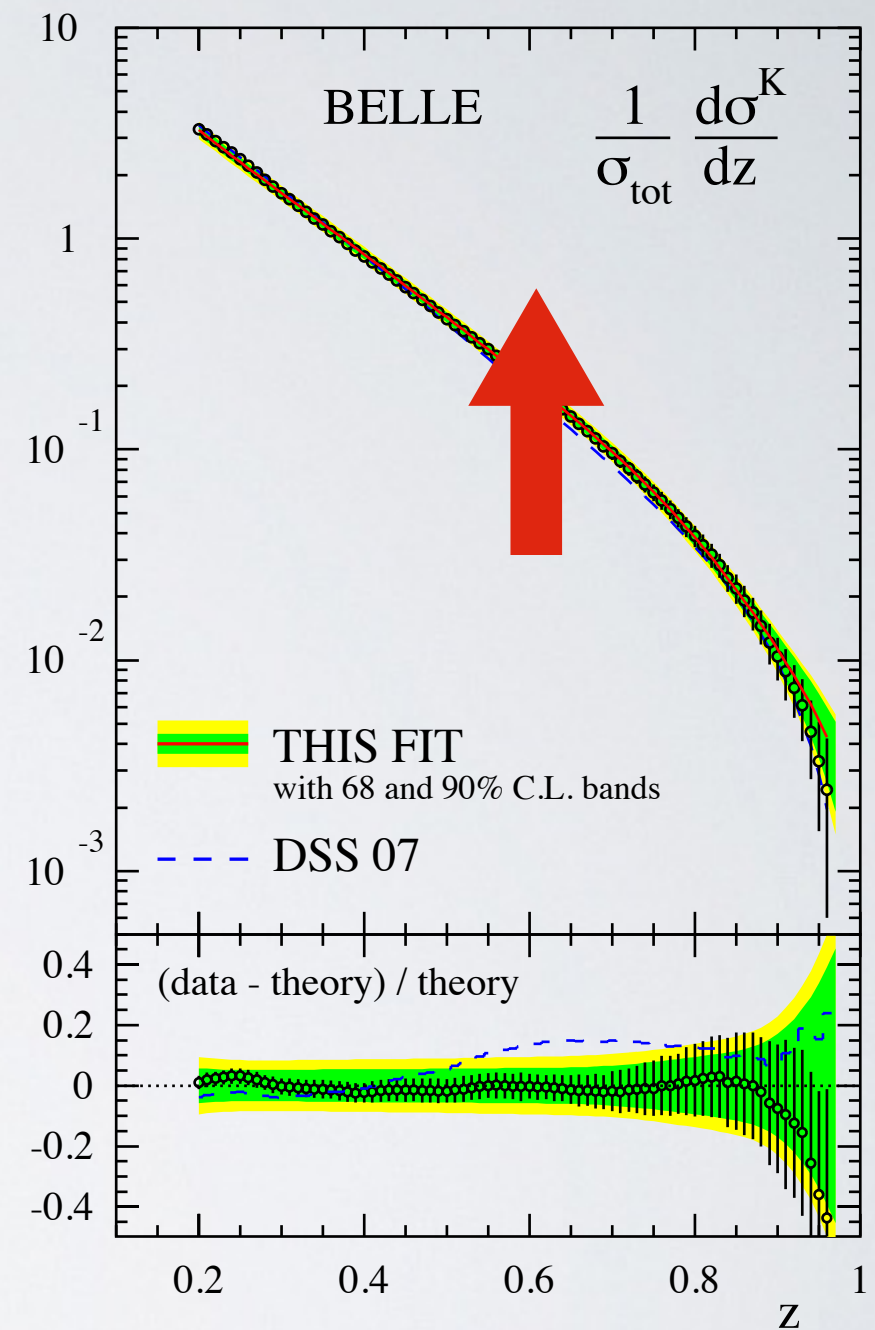
SLA: light quark singlet, charm and bottom



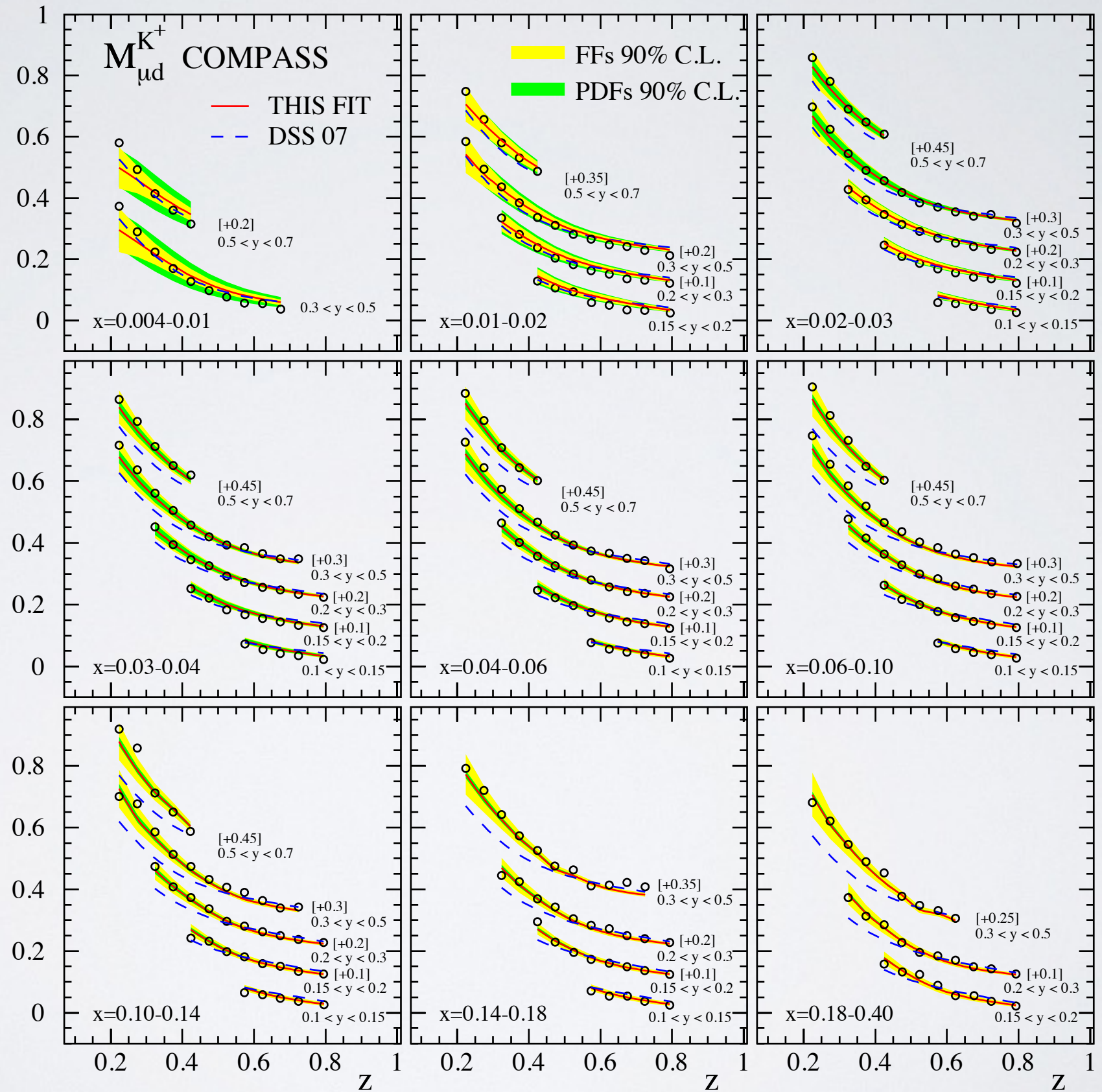
SLA: light quark singlet, charm and bottom



charm growth at large z

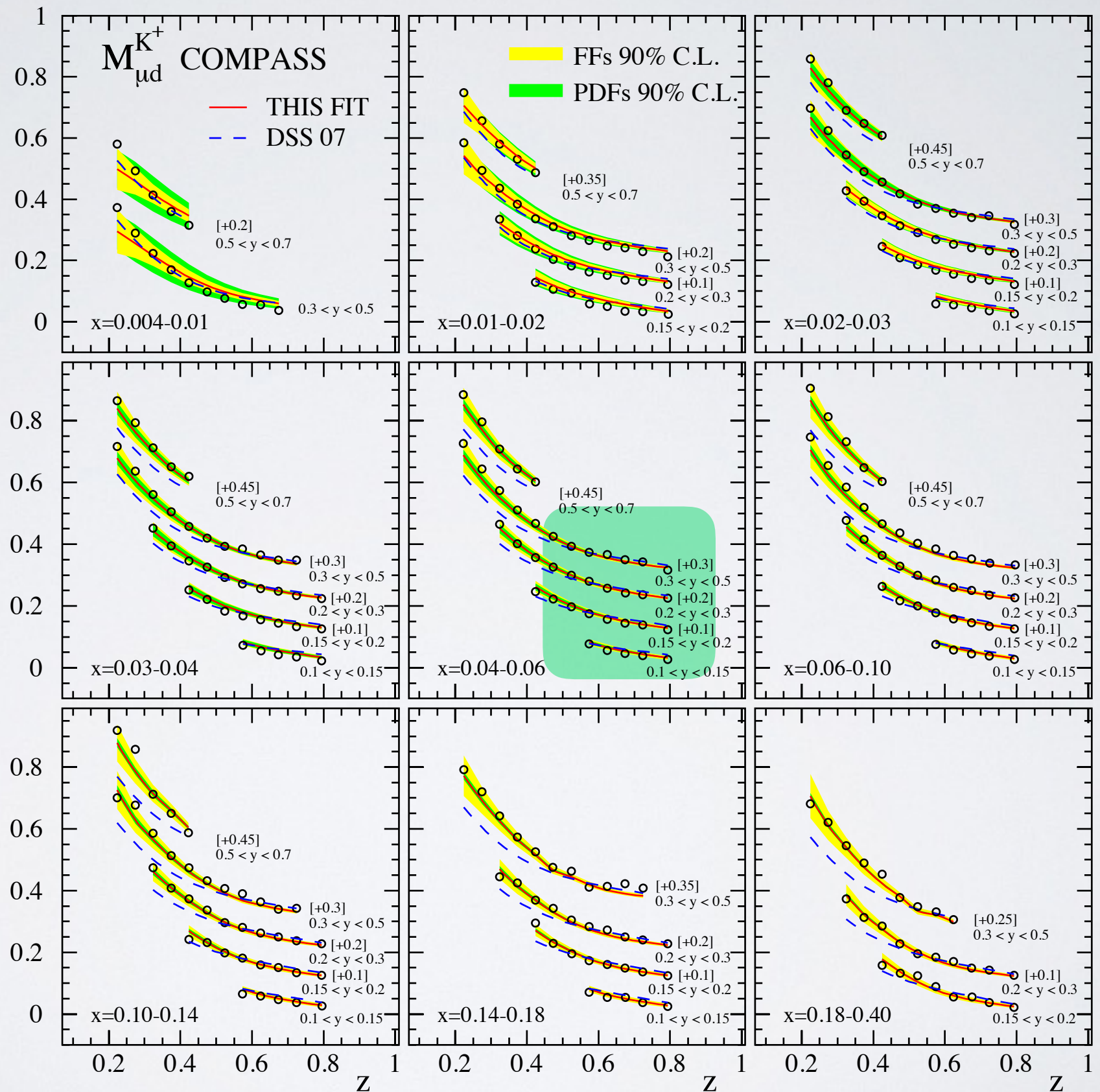


SIDIS: charge and flavor separation



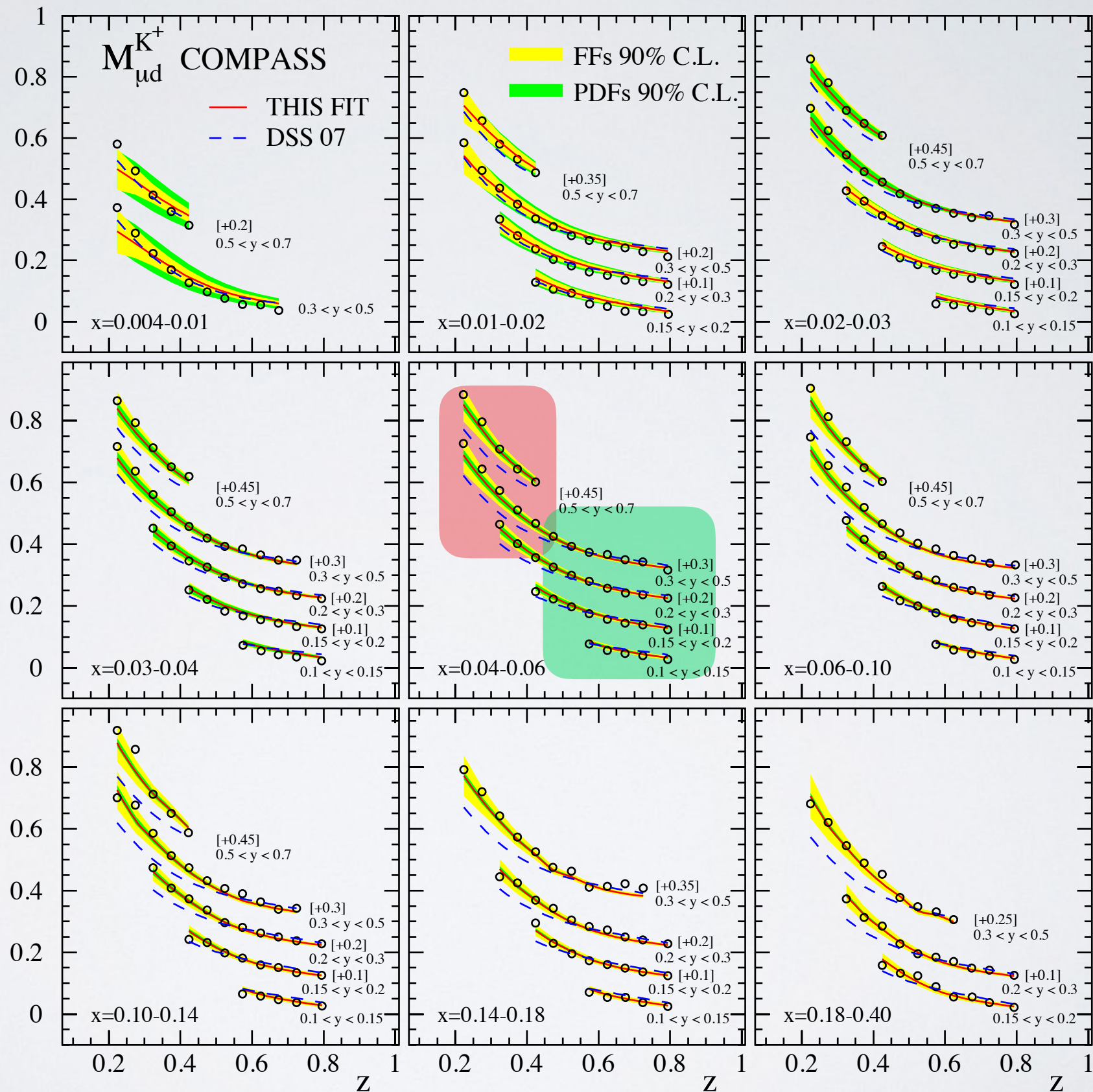
SIDIS: charge and flavor separation

no difference
at large z
(no charm)



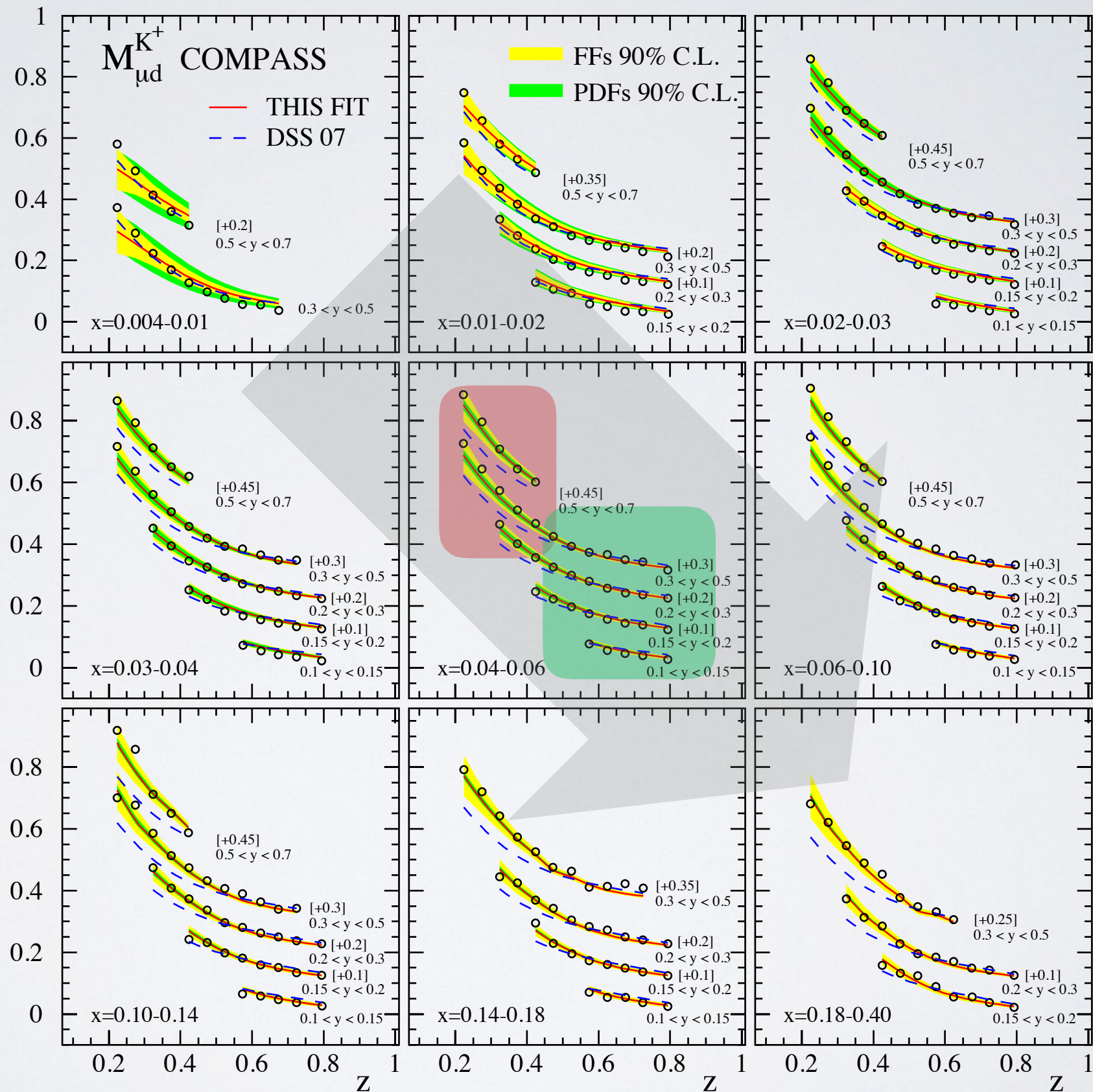
SIDIS: charge and flavor separation

low z ?
no difference
at large z
(no charm)

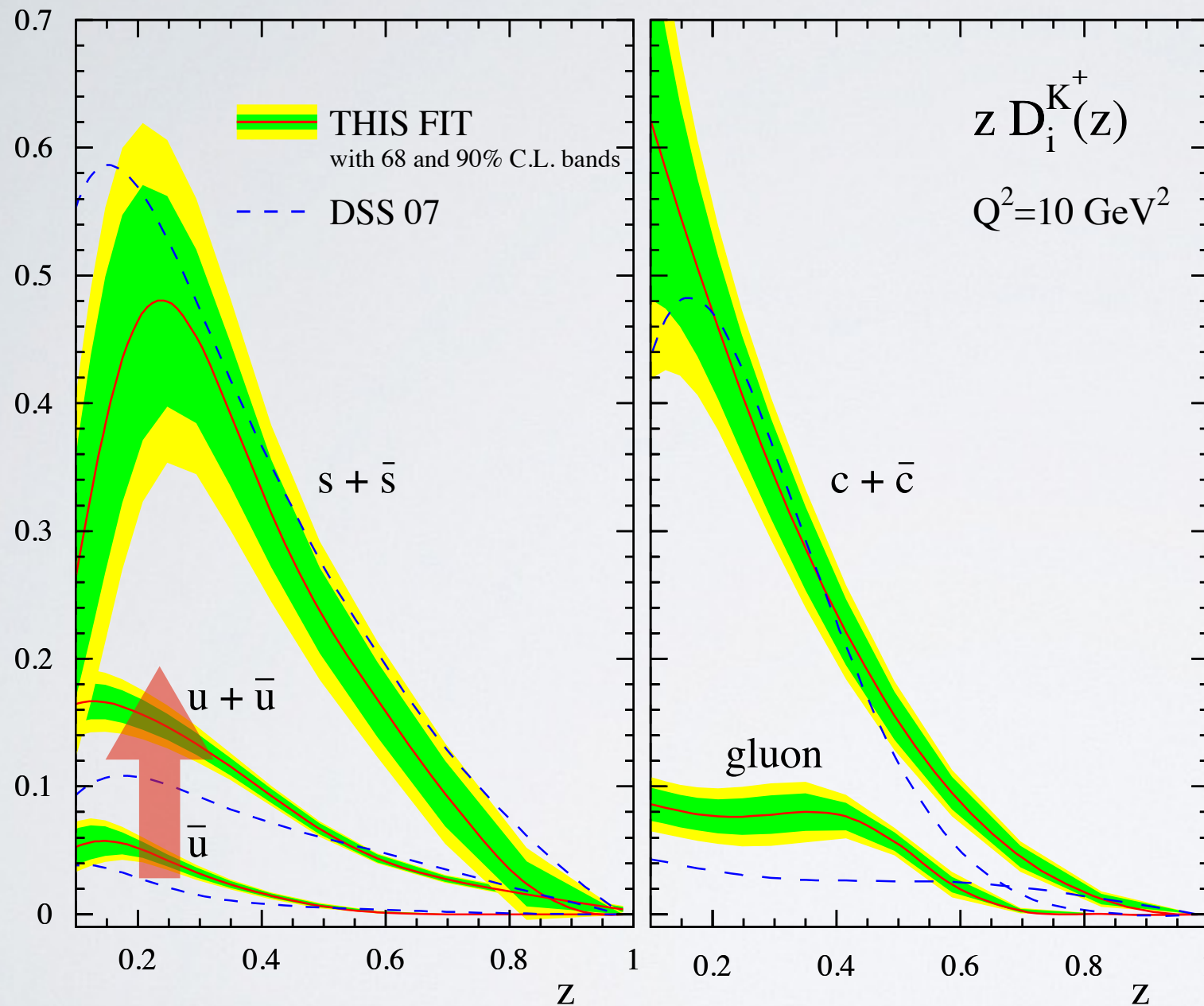


SIDIS: charge and flavor separation

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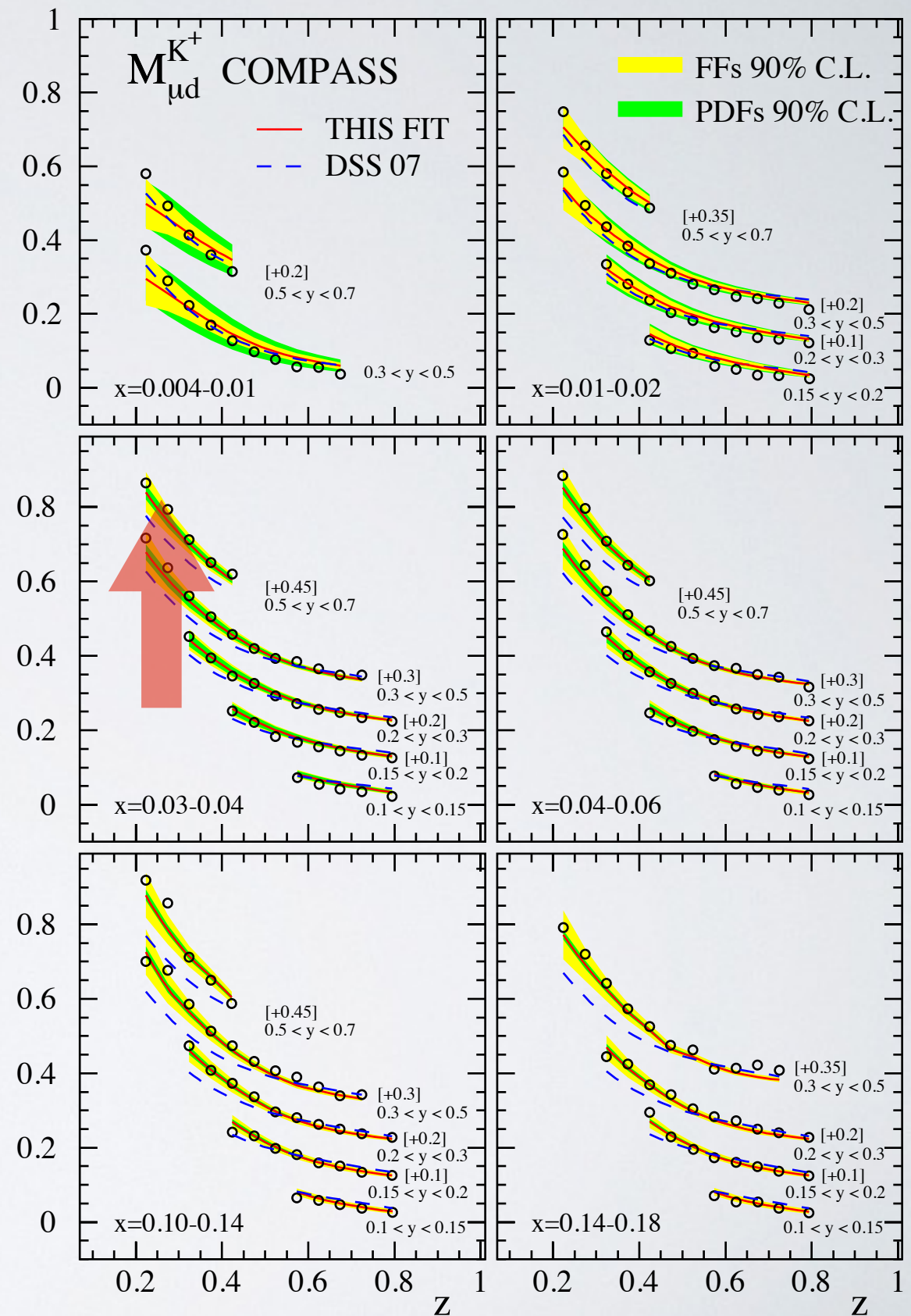


SIDIS: charge and flavor separation



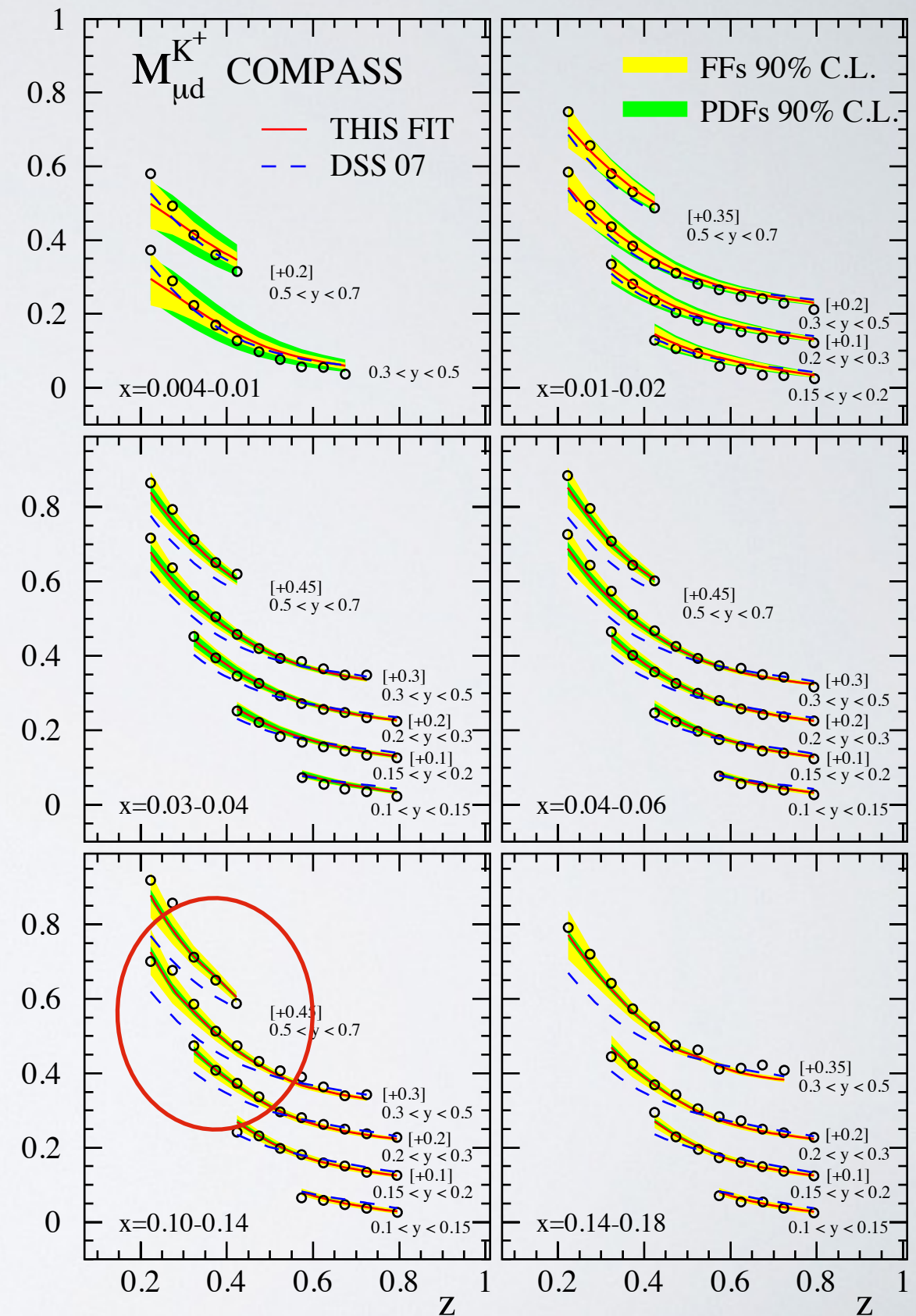
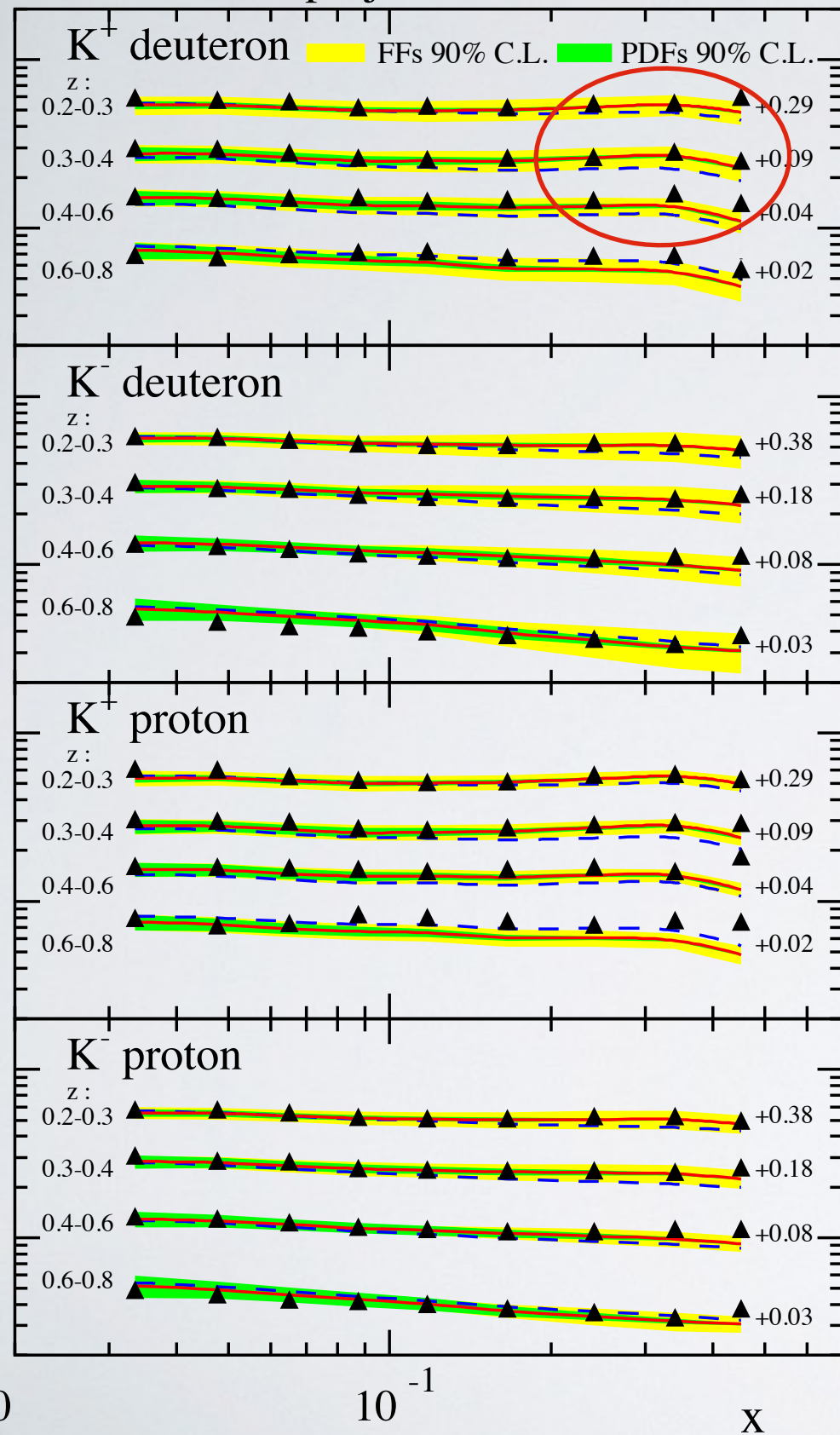
u and ubar growth at low z

this is why SIDIS matter!



SIDIS: charge and flavor separation

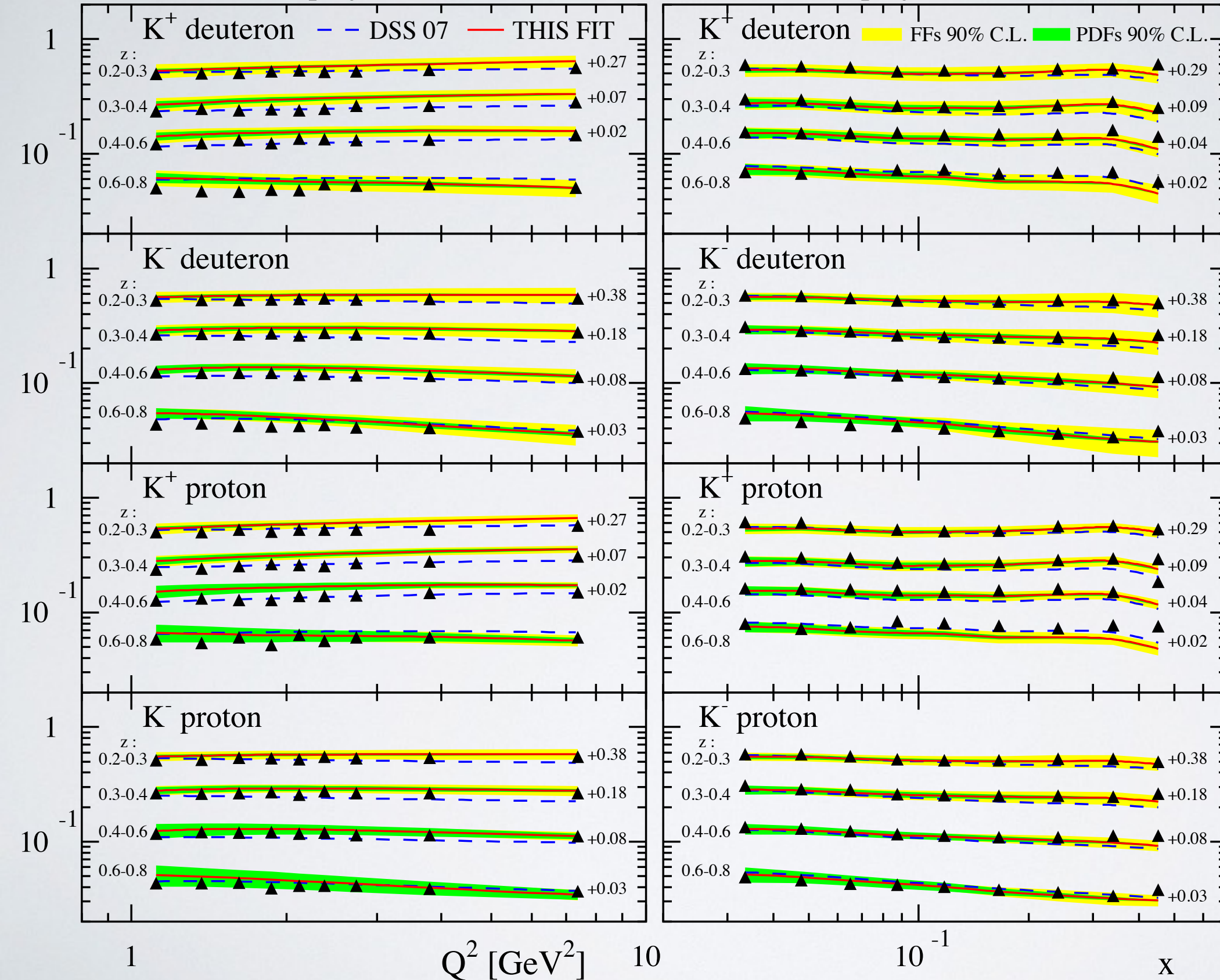
HERMES z-x projection



SIDIS: charge and flavor separation

HERMES z - Q^2 projection

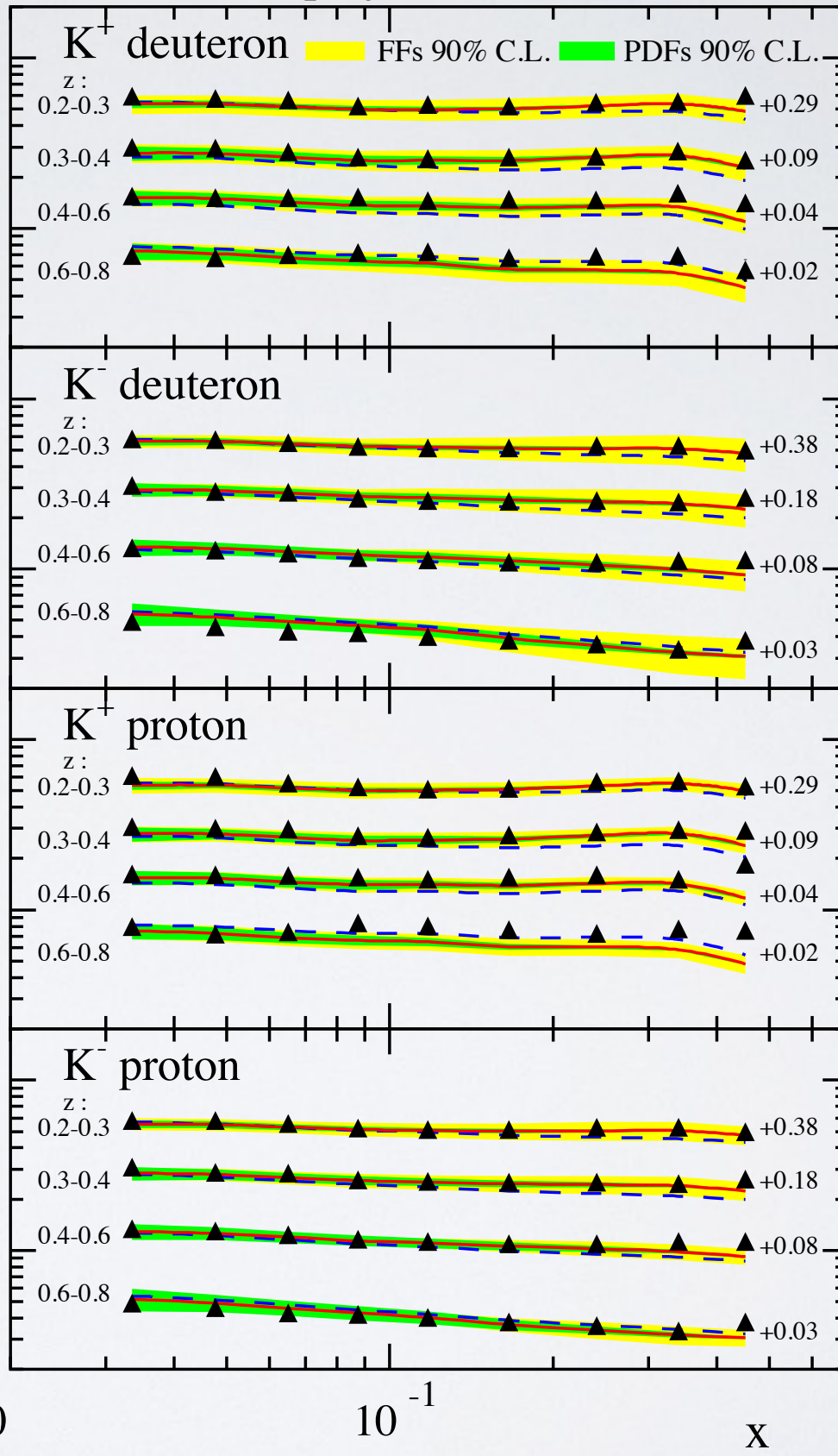
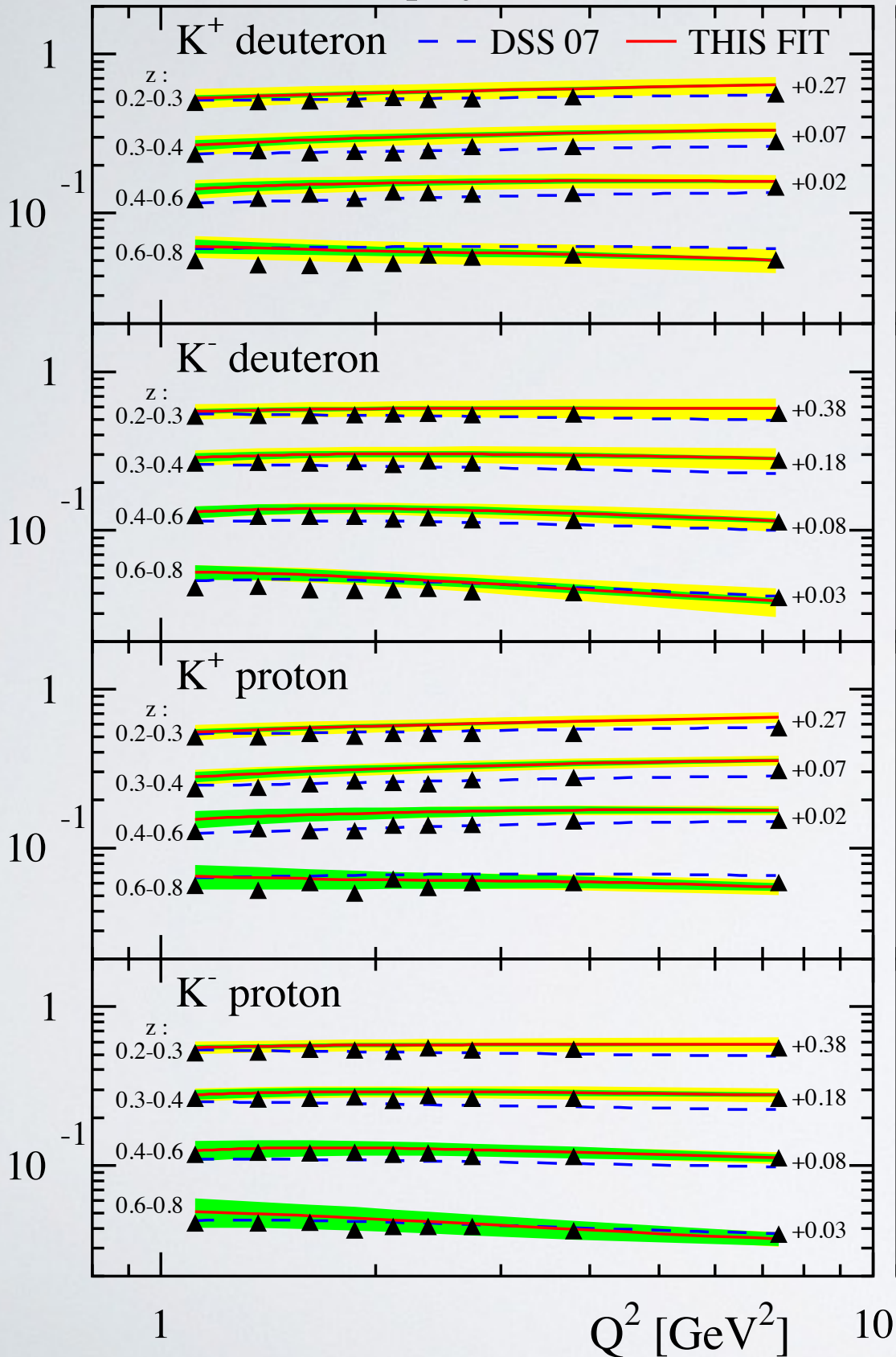
HERMES z - x projection



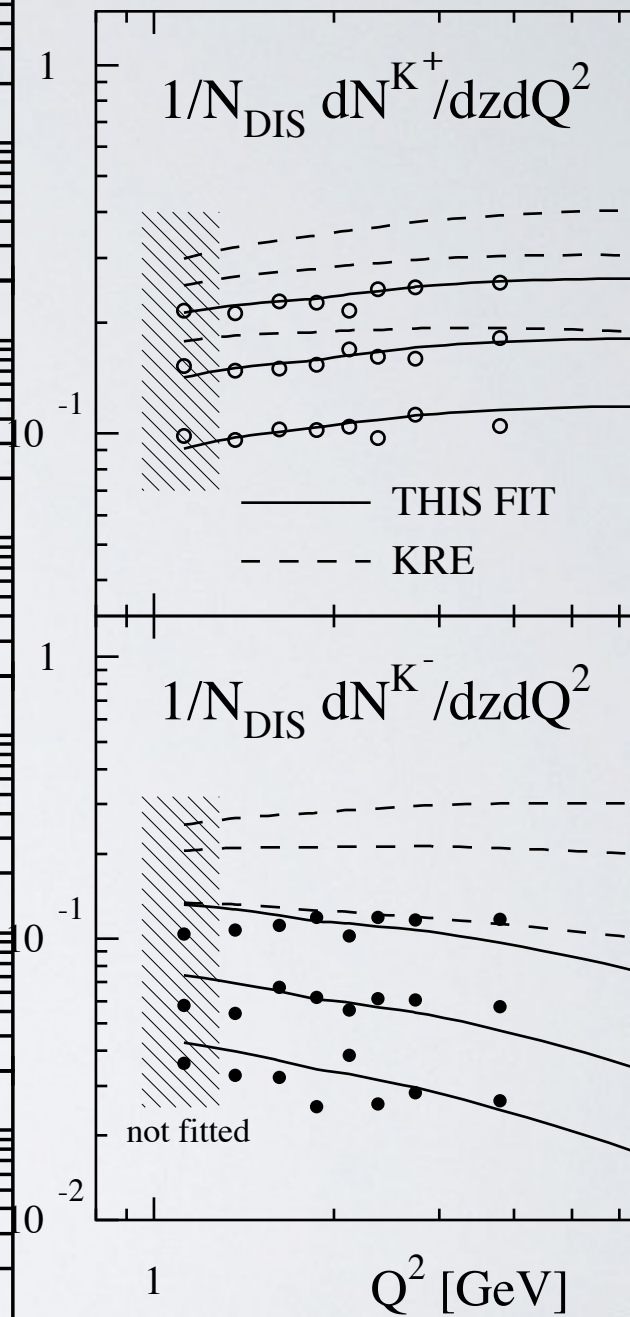
SIDIS: charge and flavor separation

HERMES z - Q^2 projection

HERMES z - x projection



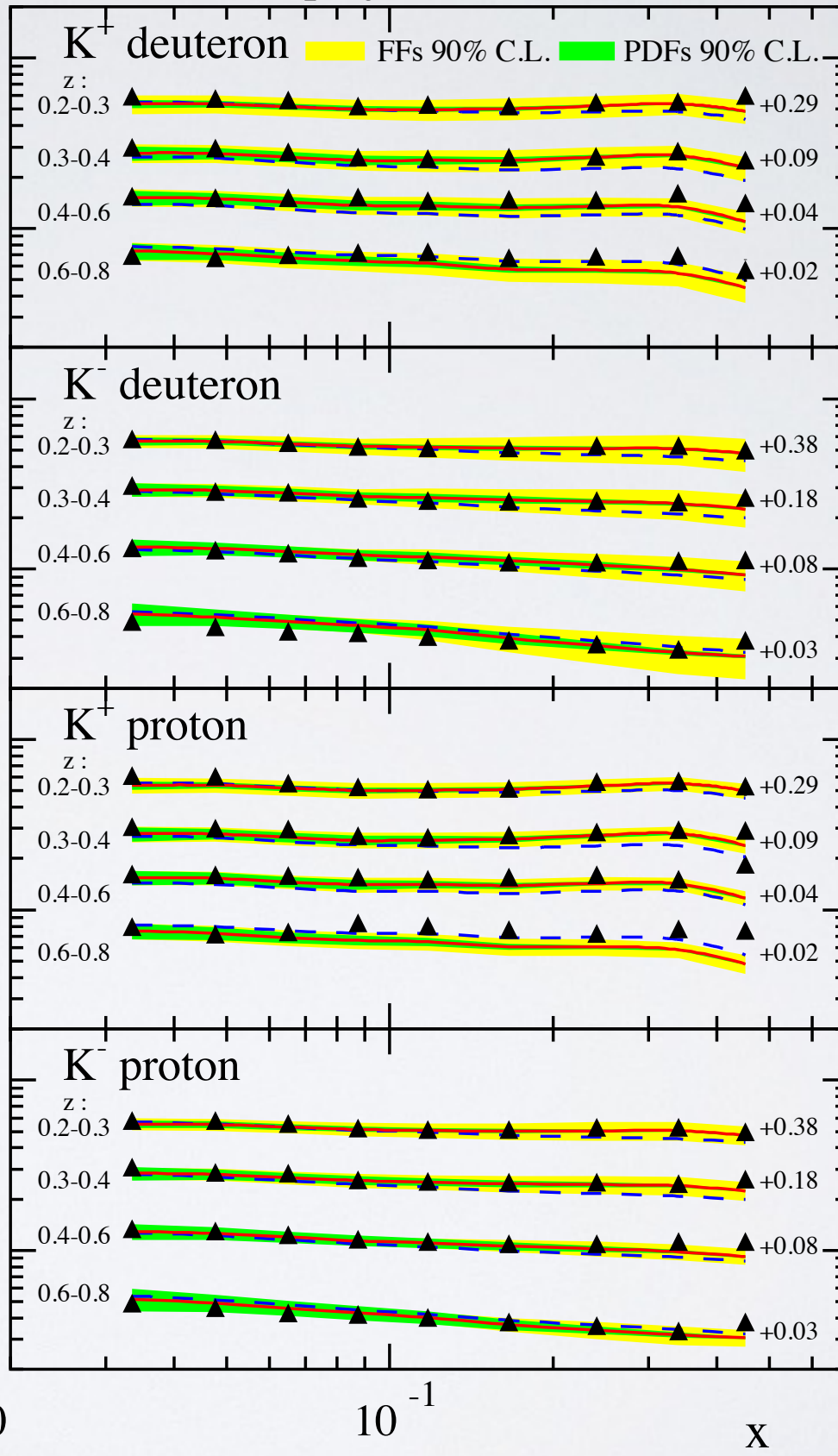
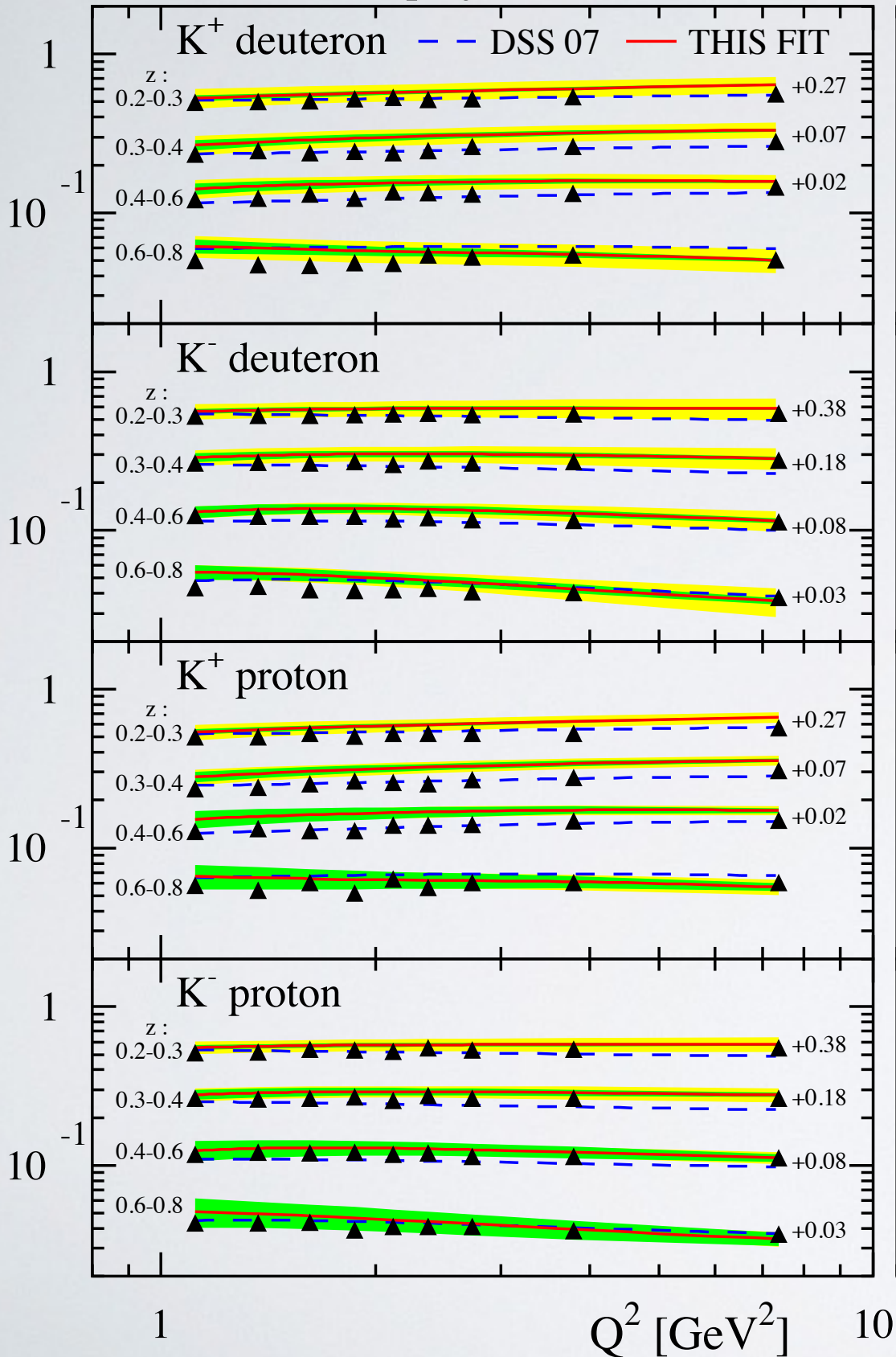
DSS07+MRST04



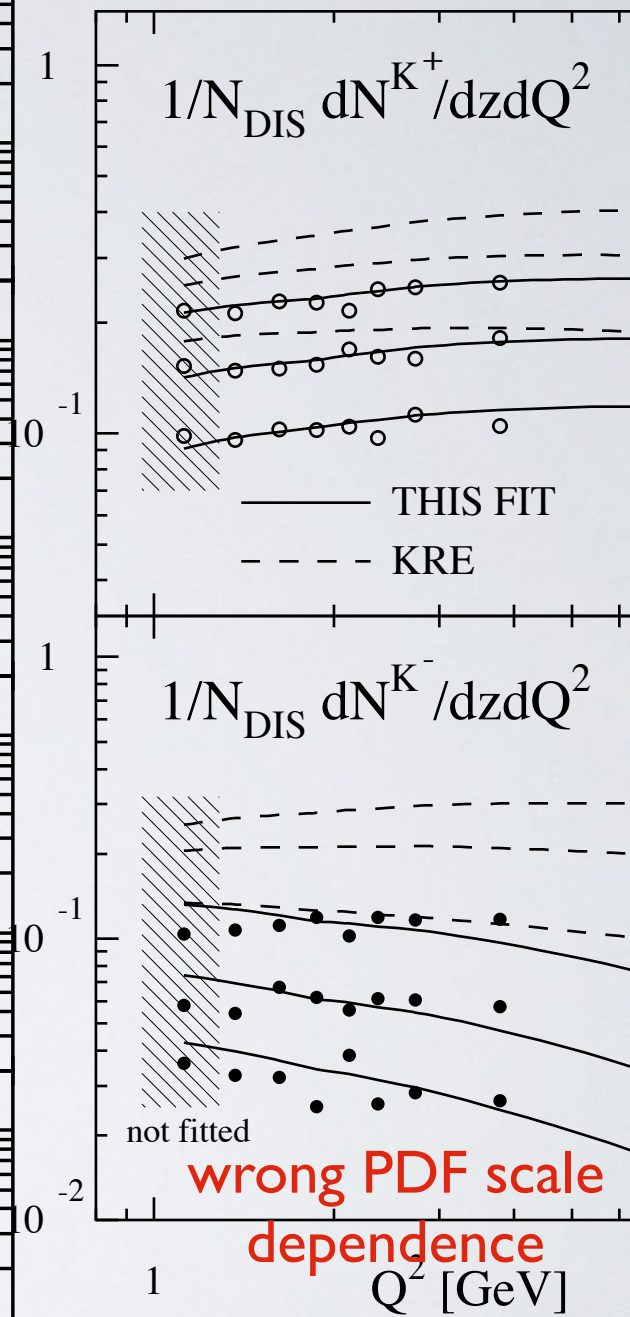
SIDIS: charge and flavor separation

HERMES z - Q^2 projection

HERMES z - x projection

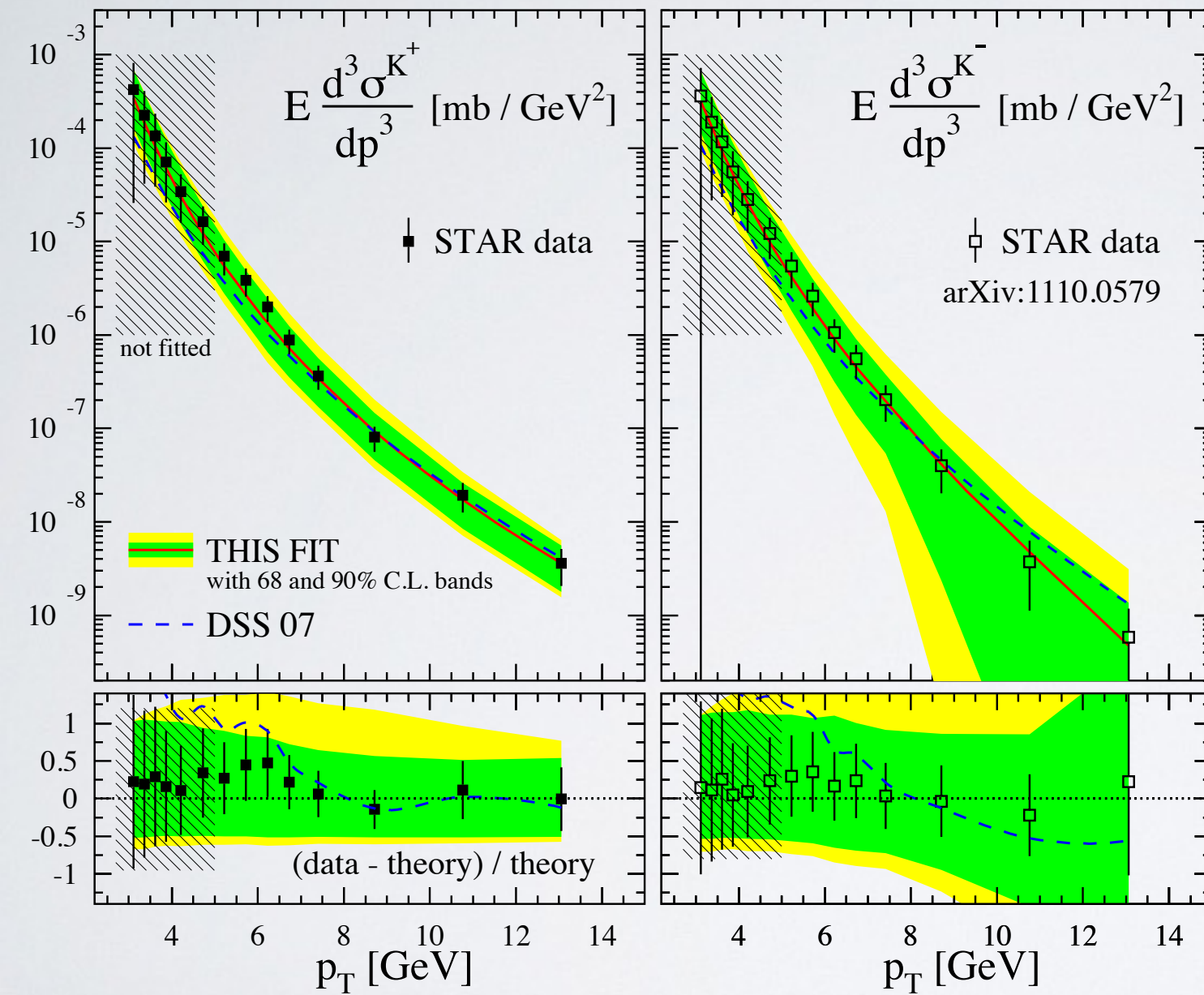


DSS07+MRST04

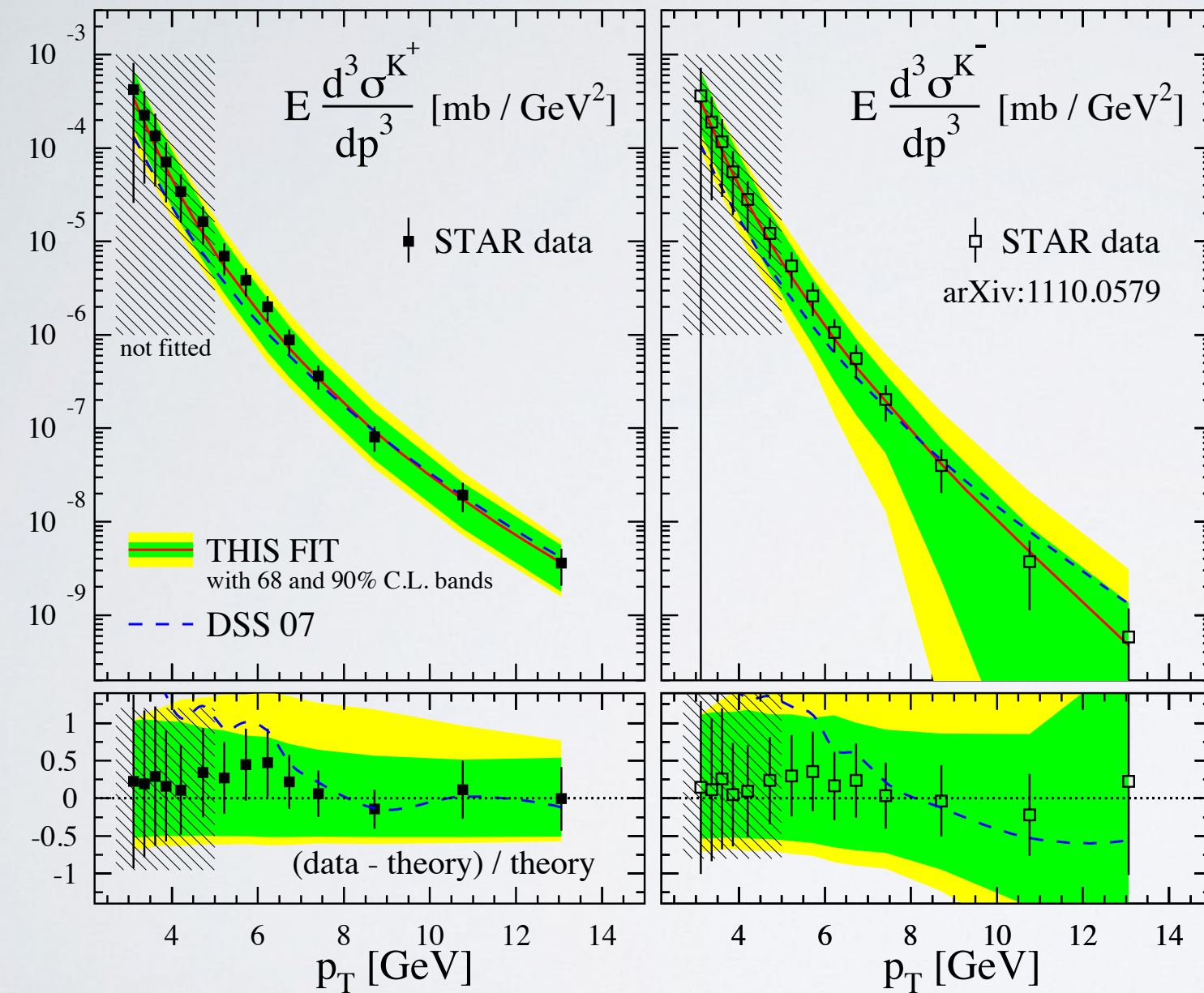


pp: gluon fragmentation on equal footing (quark cross check)

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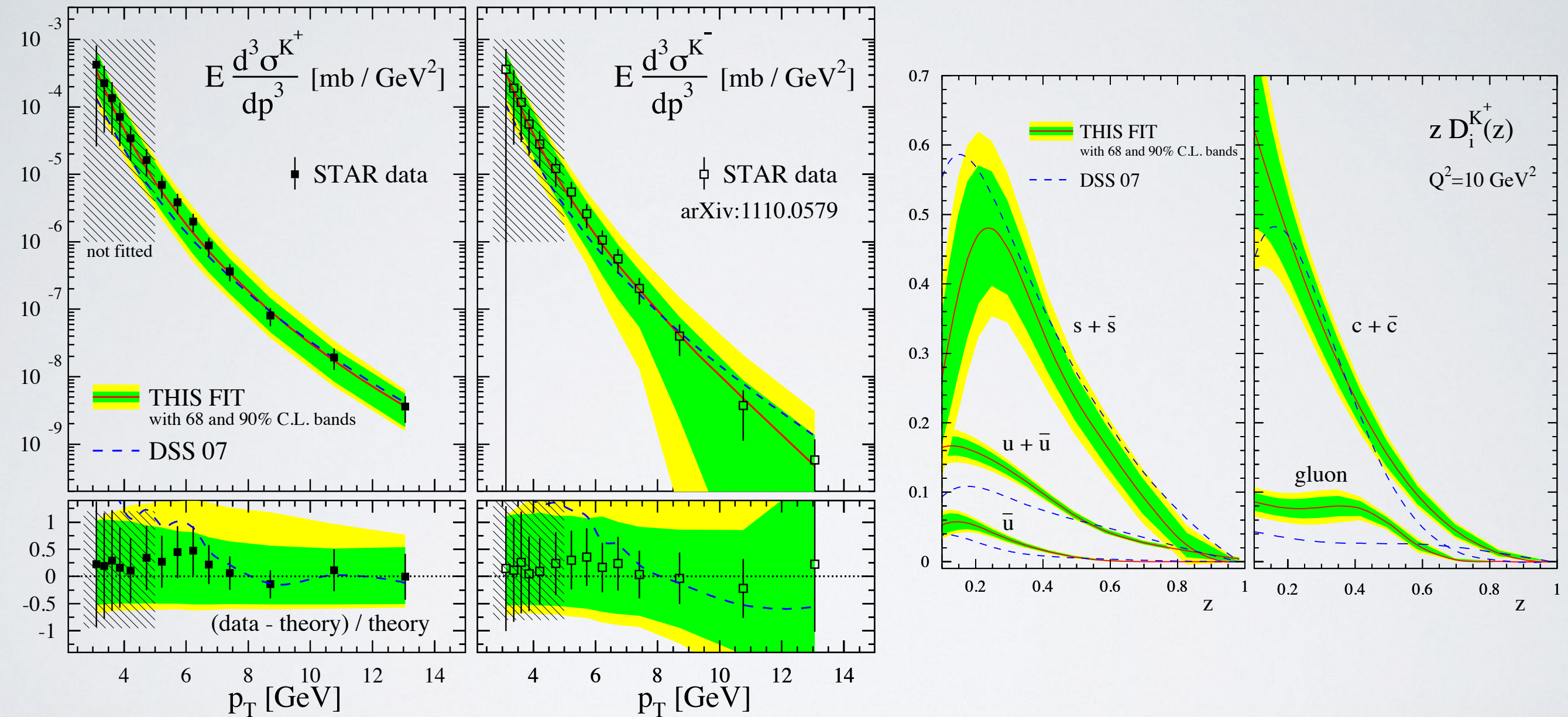


pp: gluon fragmentation on equal footing (quark cross check)



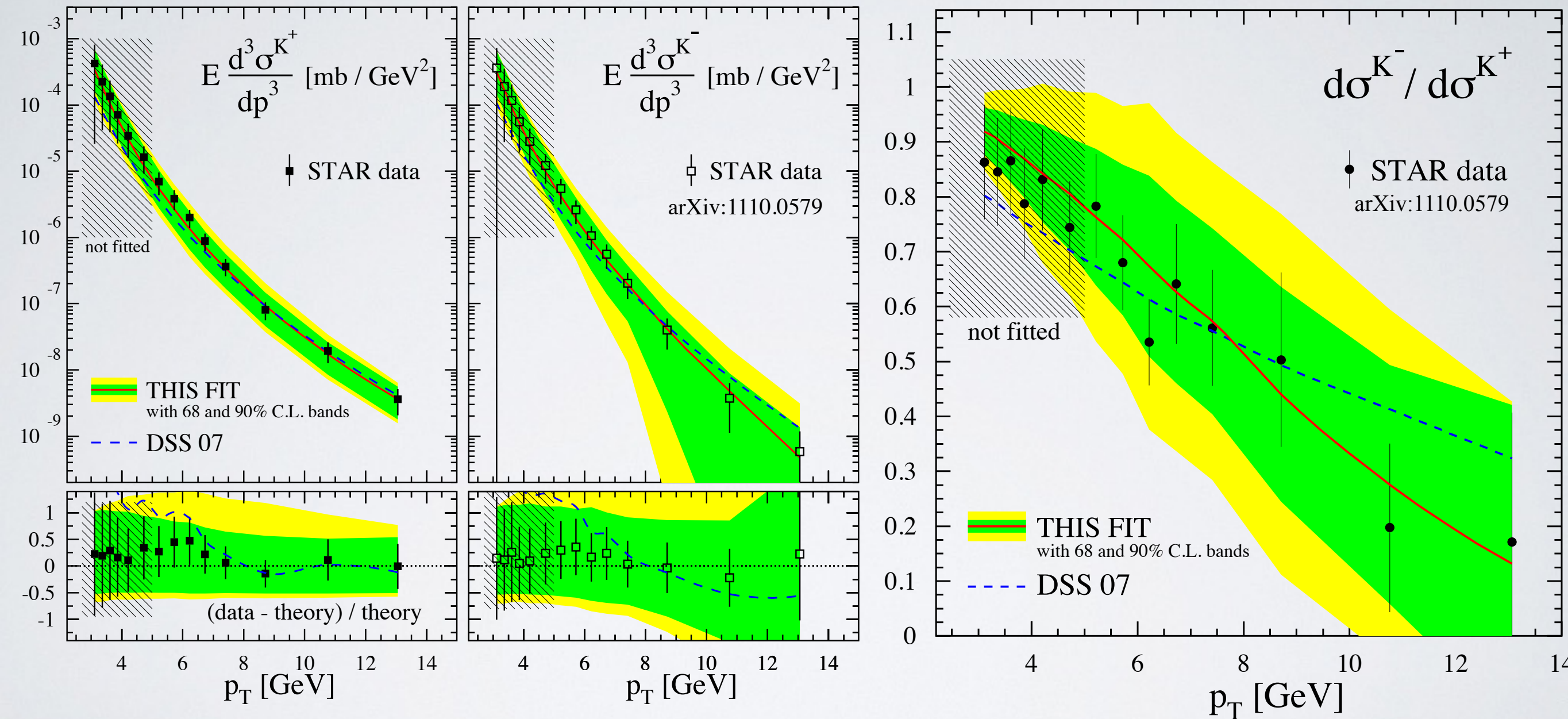
gluon FF into kaons relies mainly on these data!

pp: gluon fragmentation on equal footing (quark cross check)

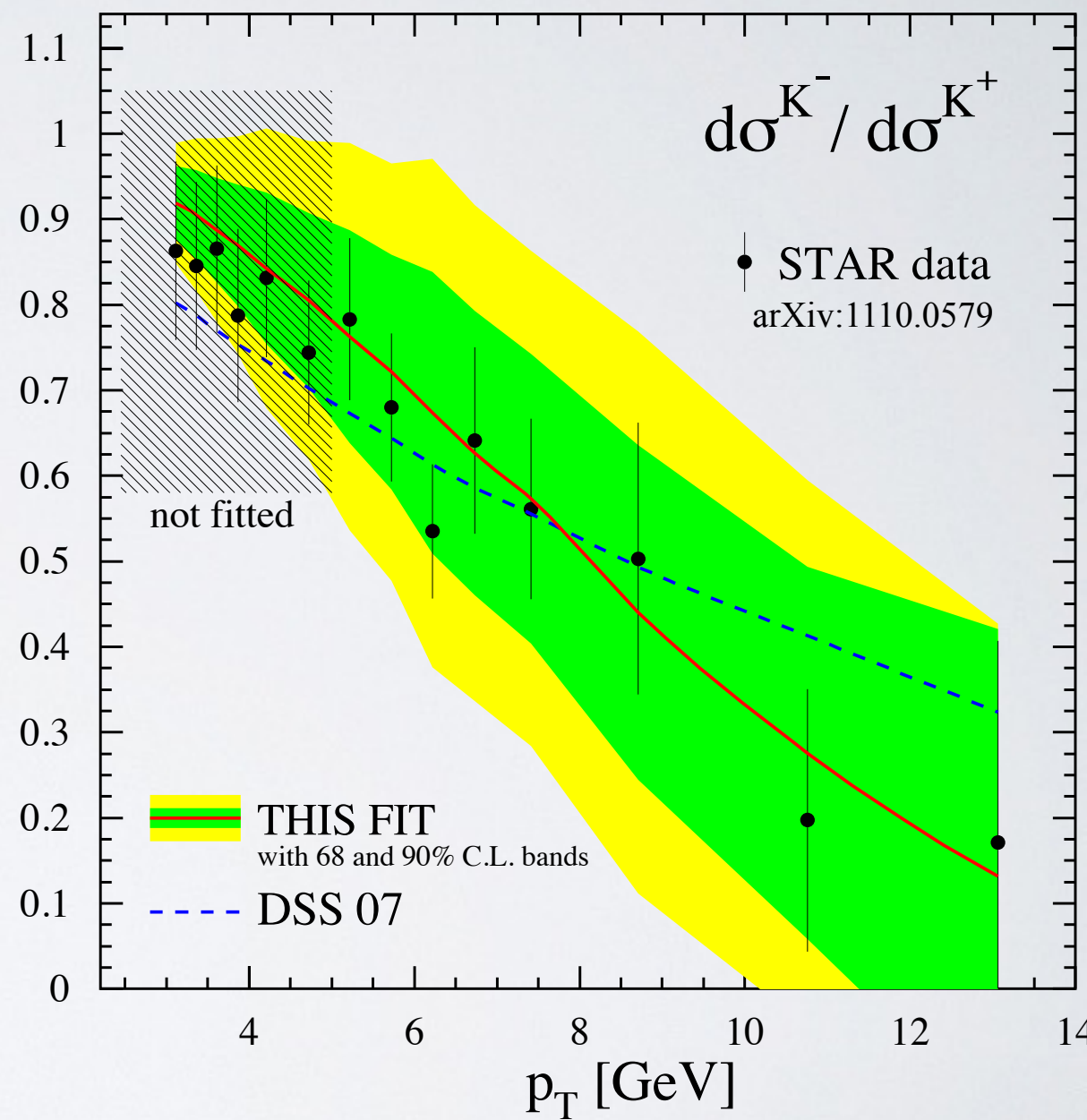
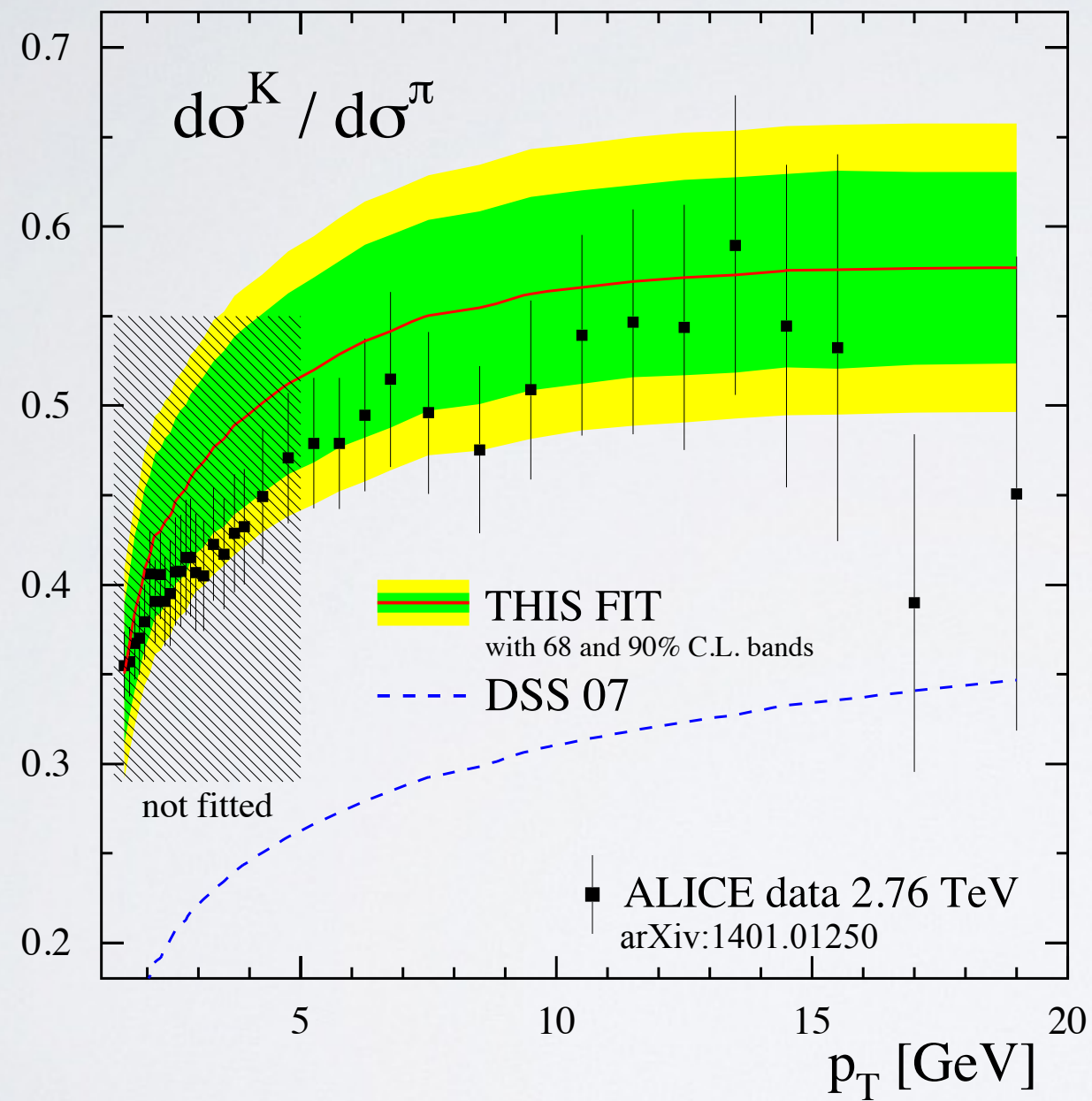


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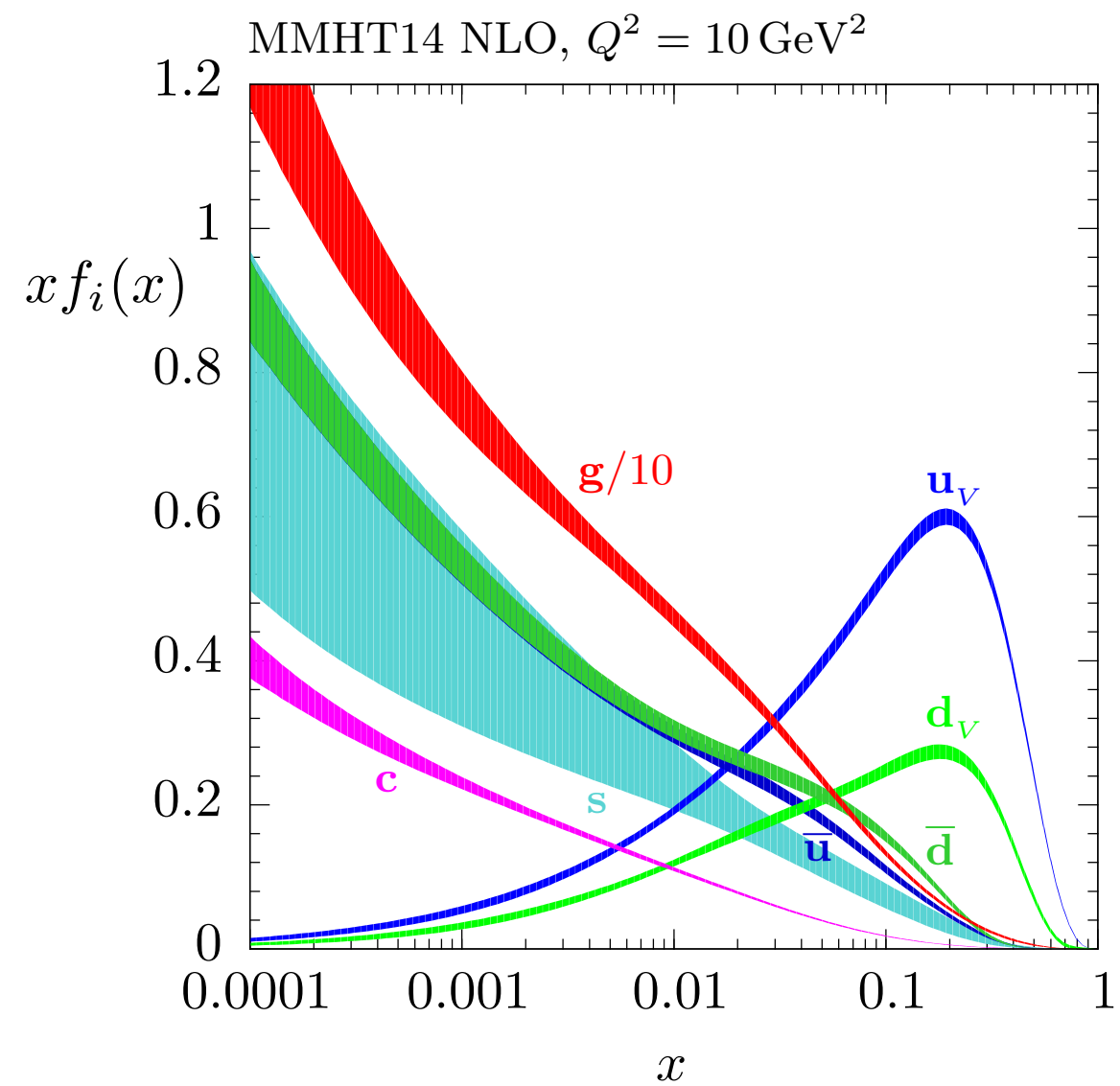
pp: gluon fragmentation on equal footing (quark cross check)



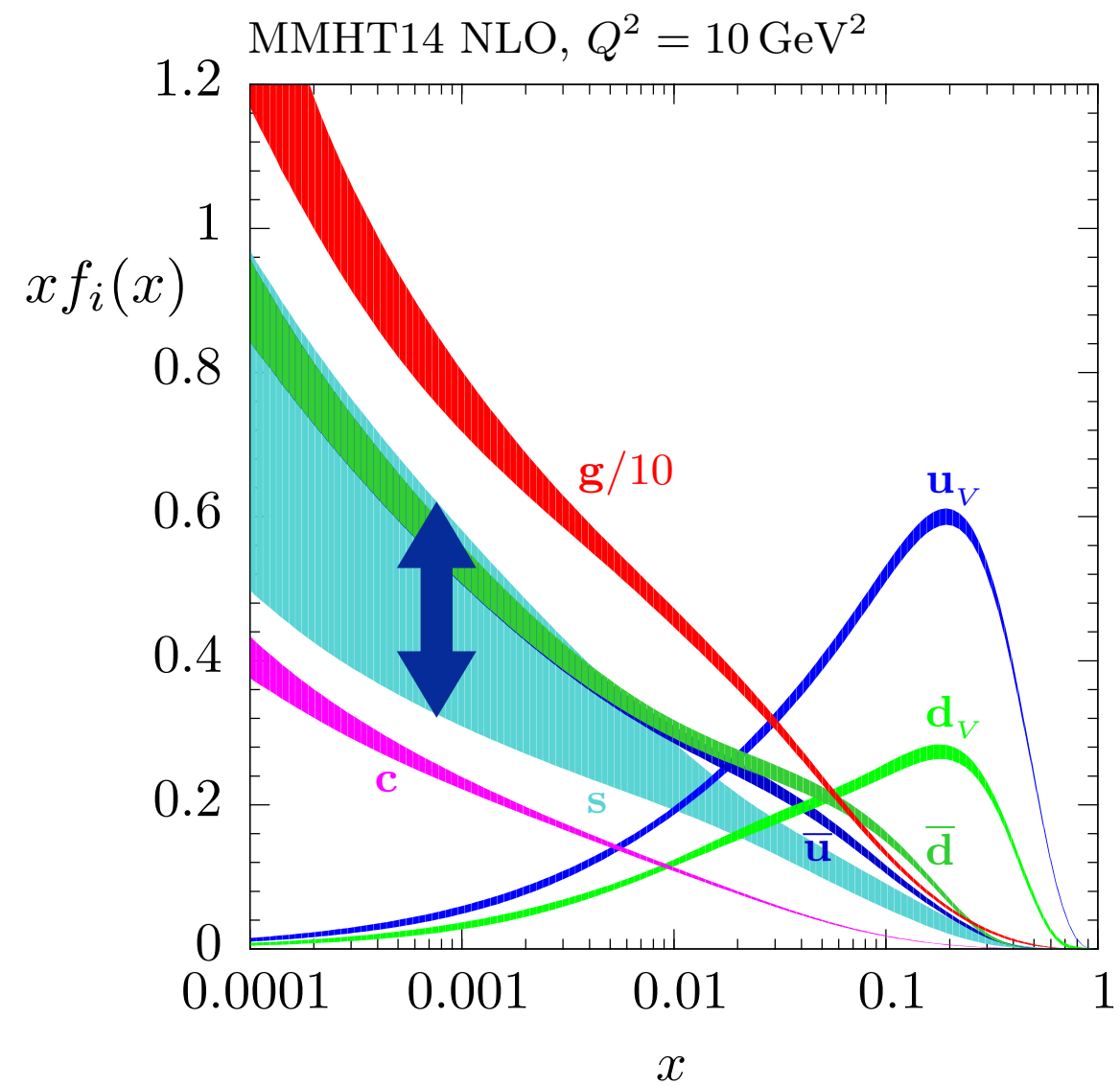
pp: gluon fragmentation on equal footing (quark cross check)



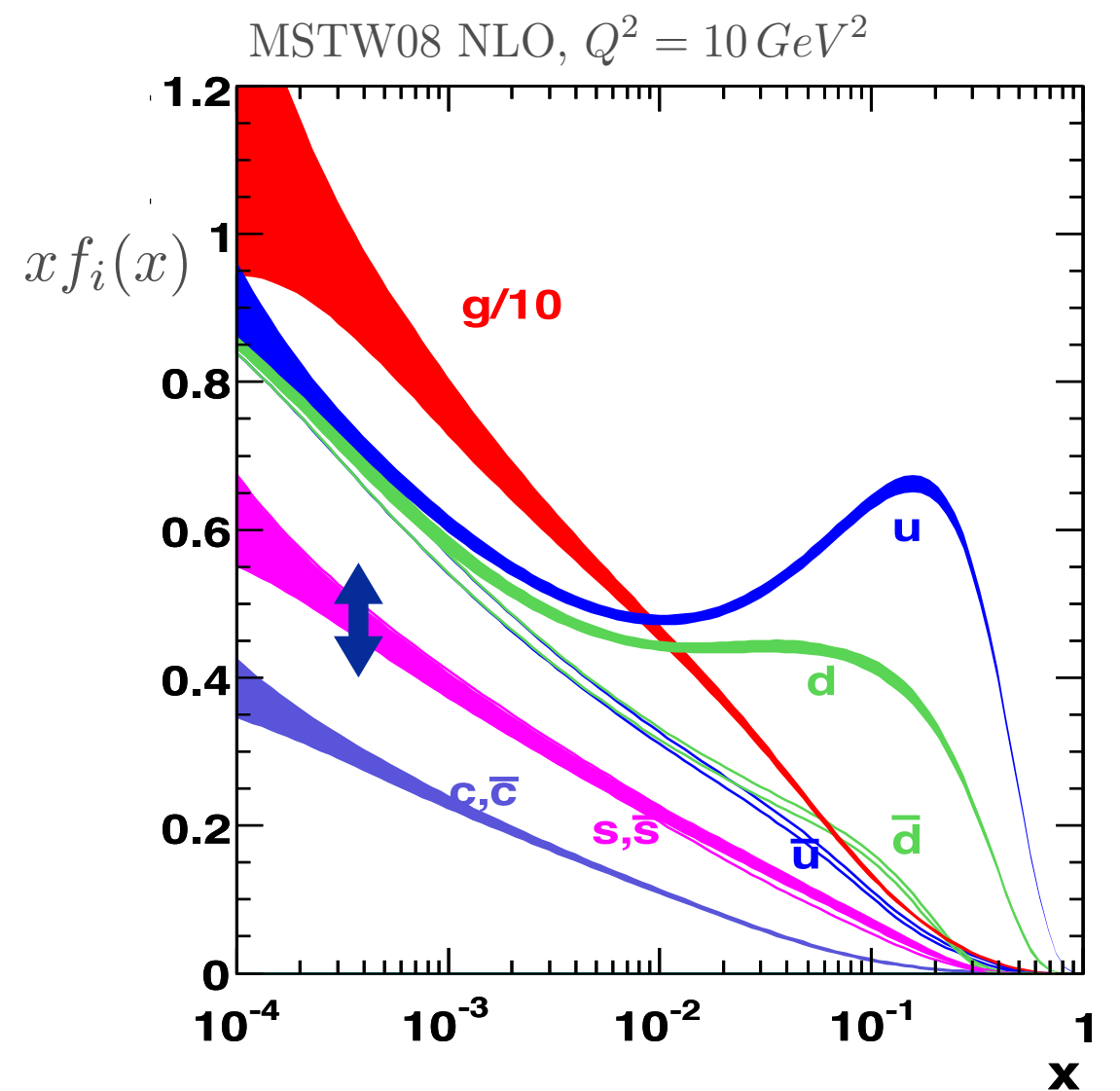
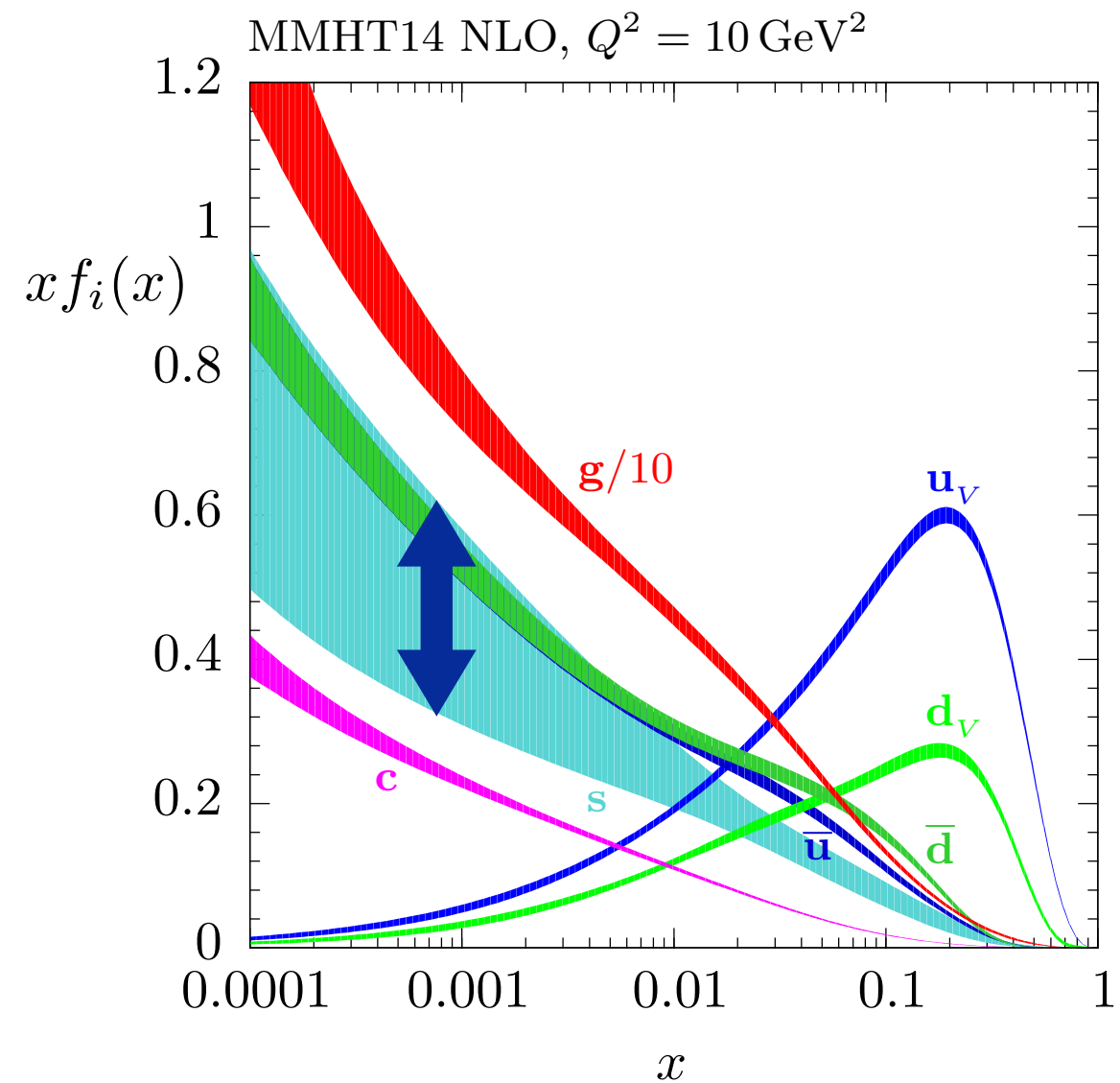
are PDFs that good?



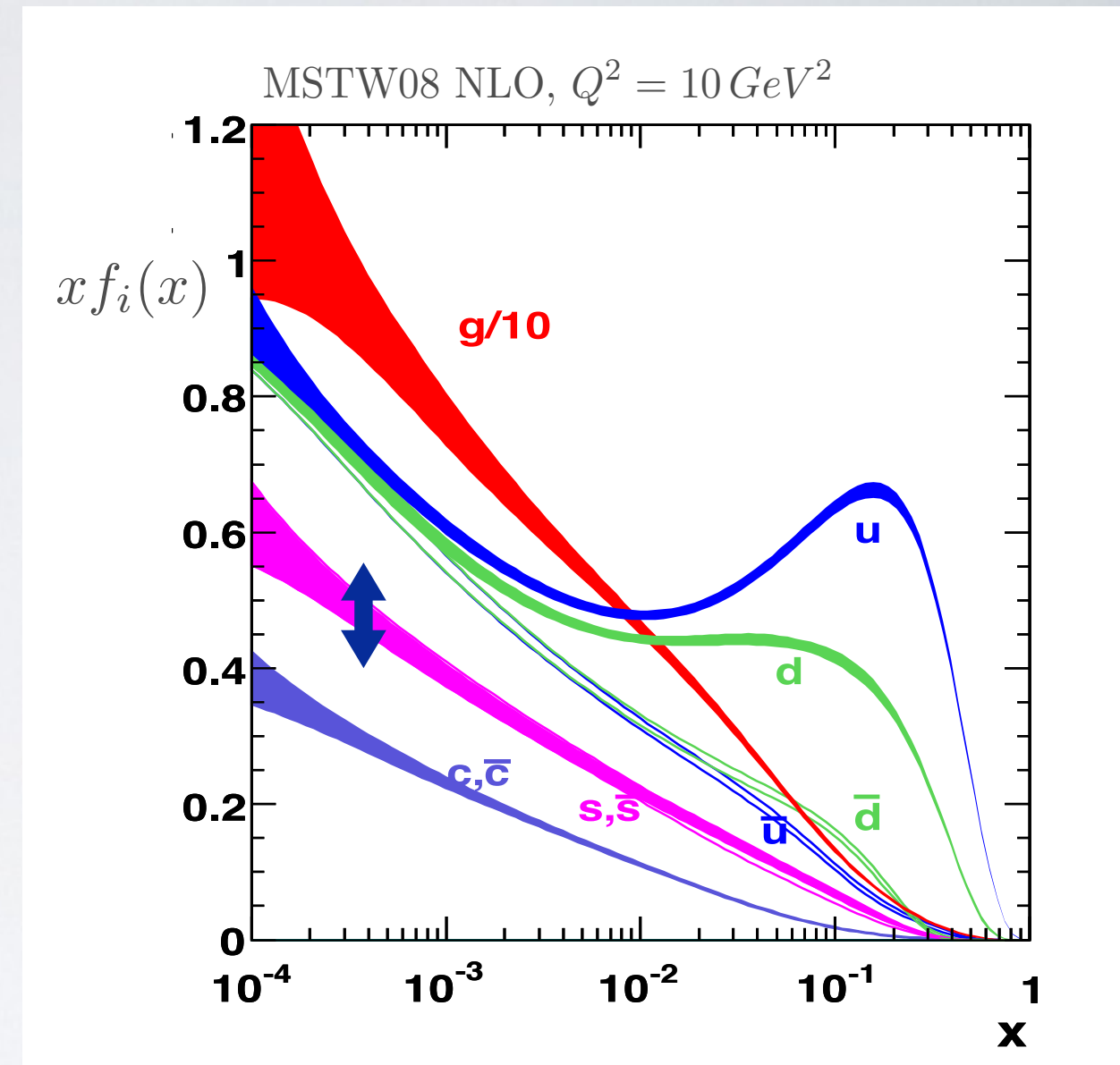
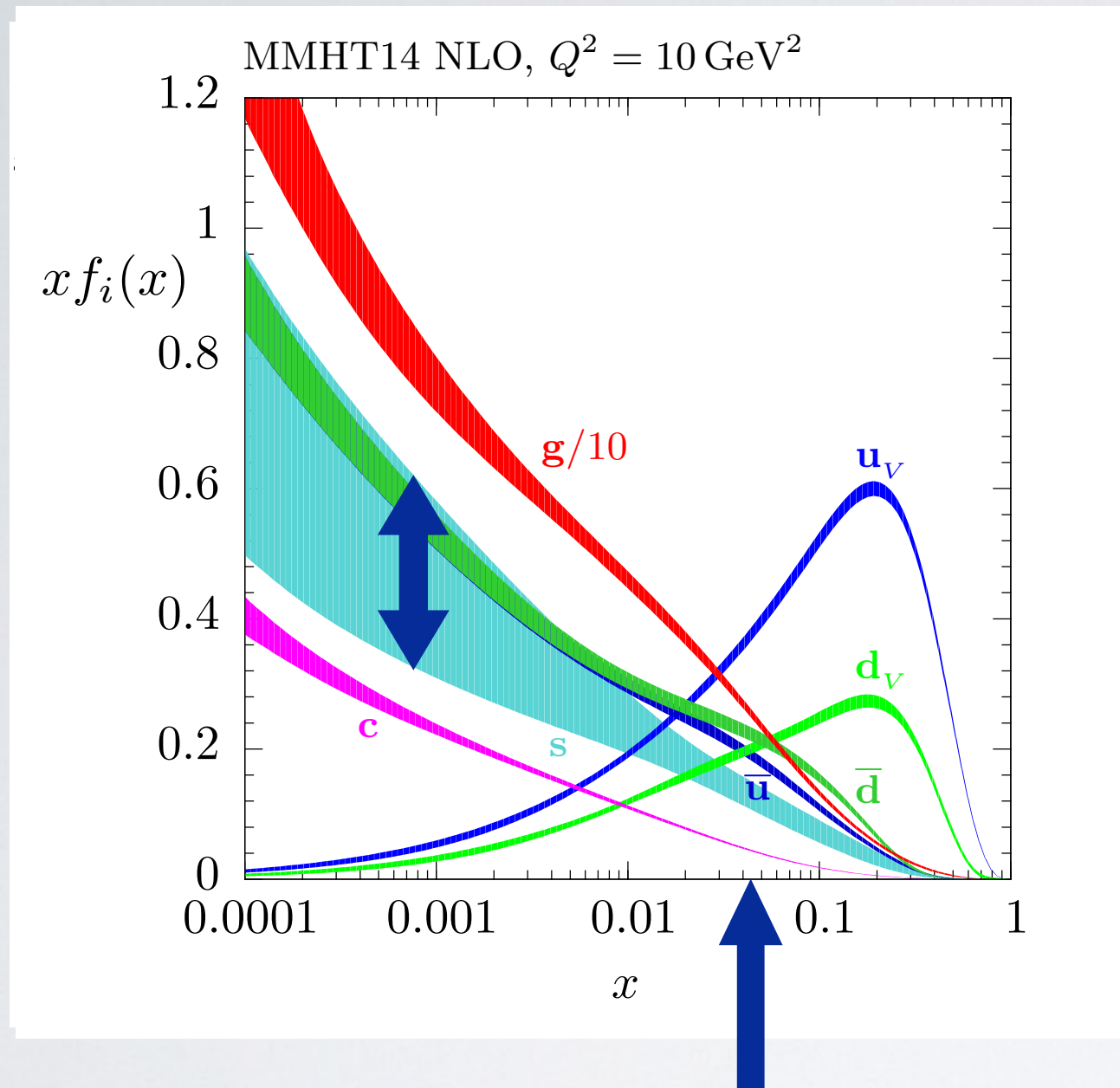
are PDFs that good?



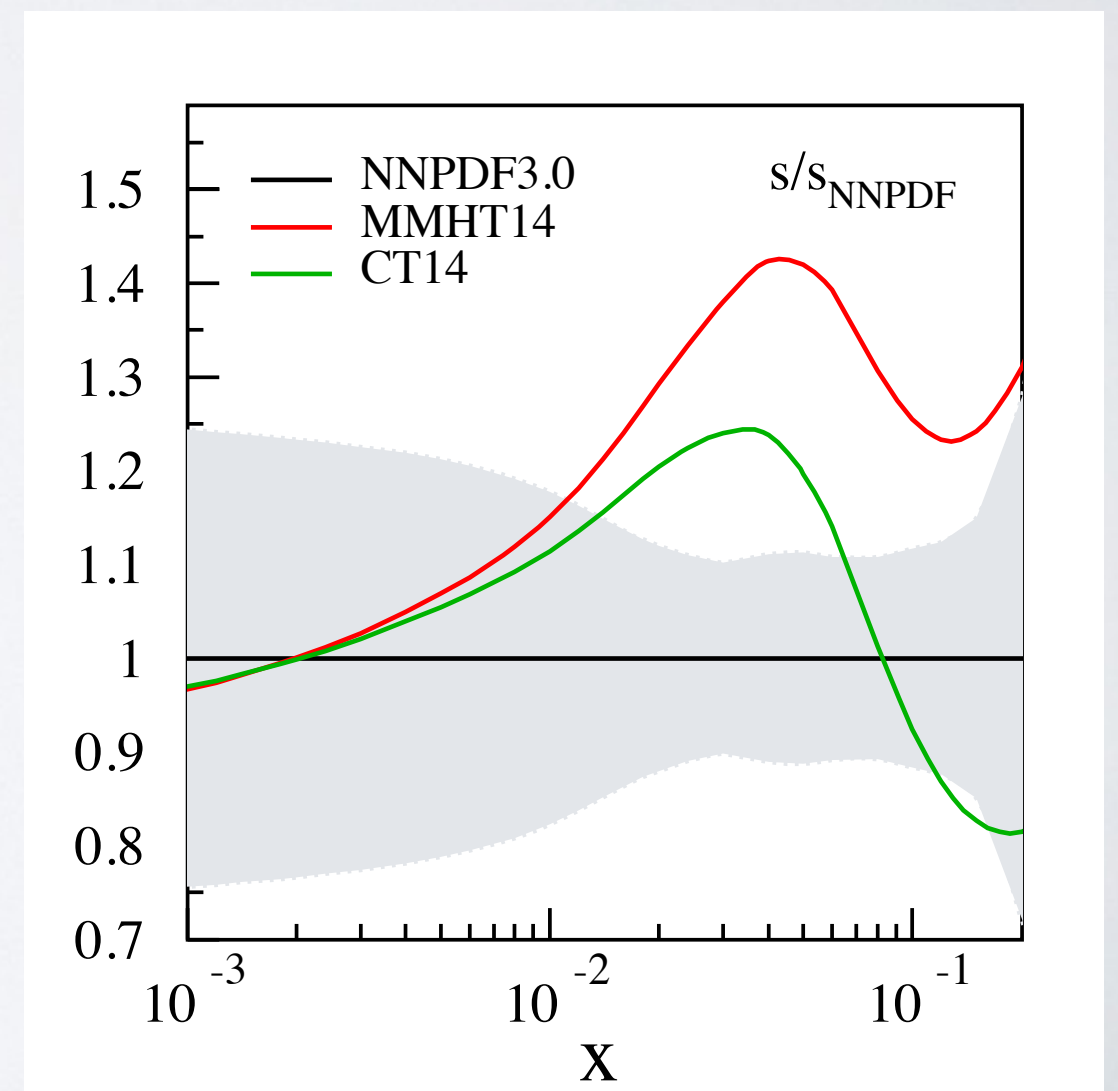
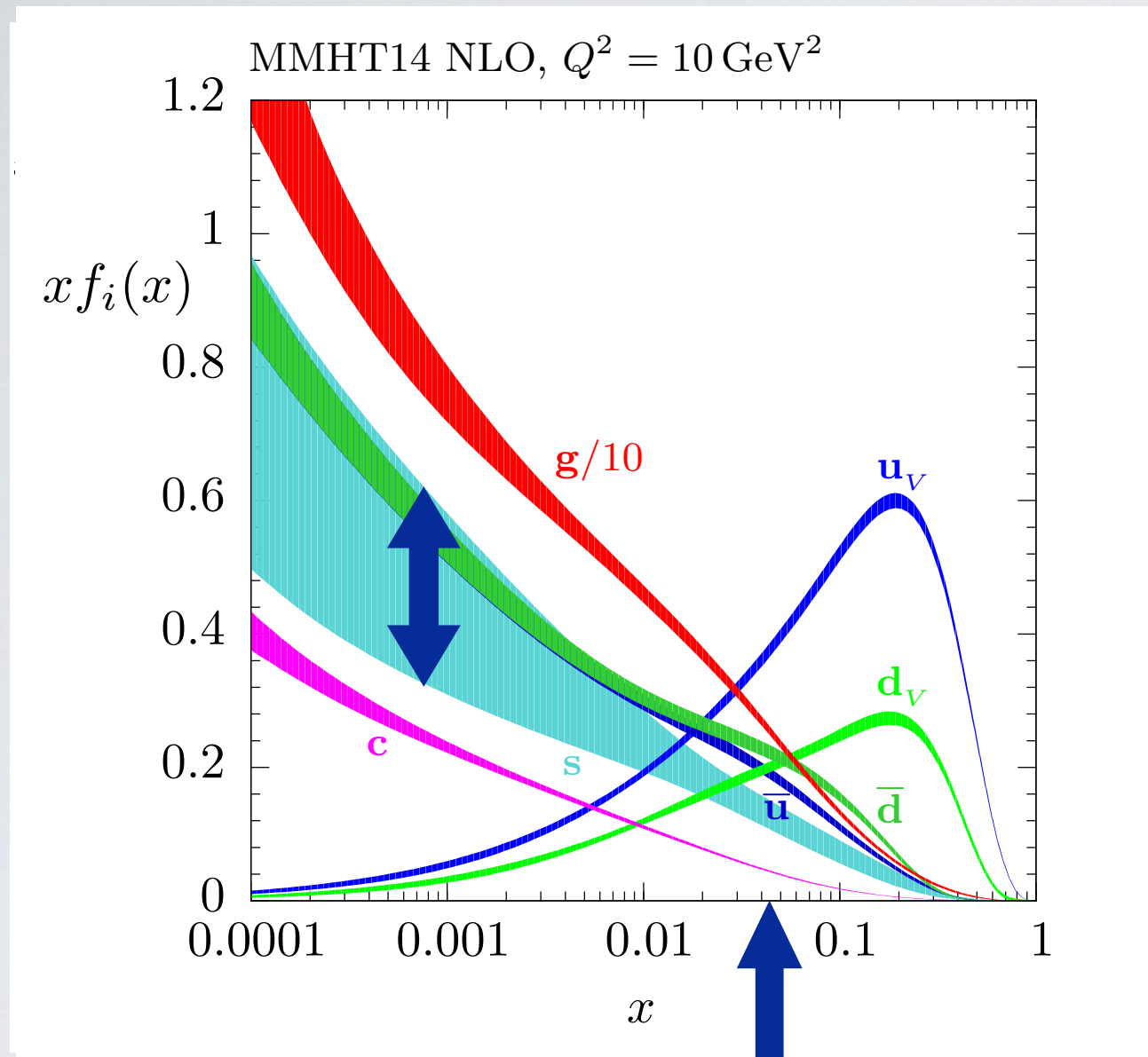
are PDFs that good?



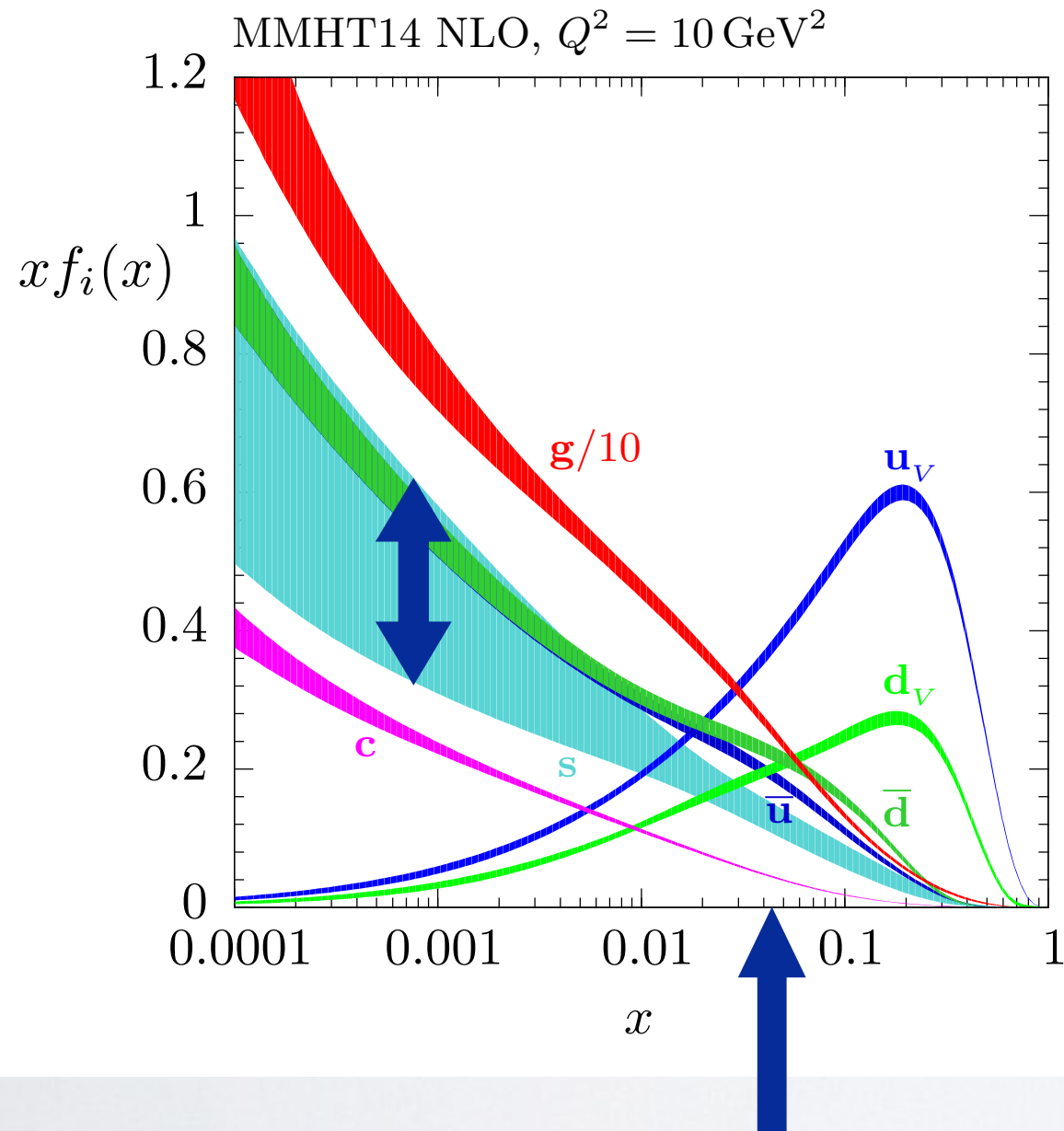
are PDFs that good?



are PDFs that good?



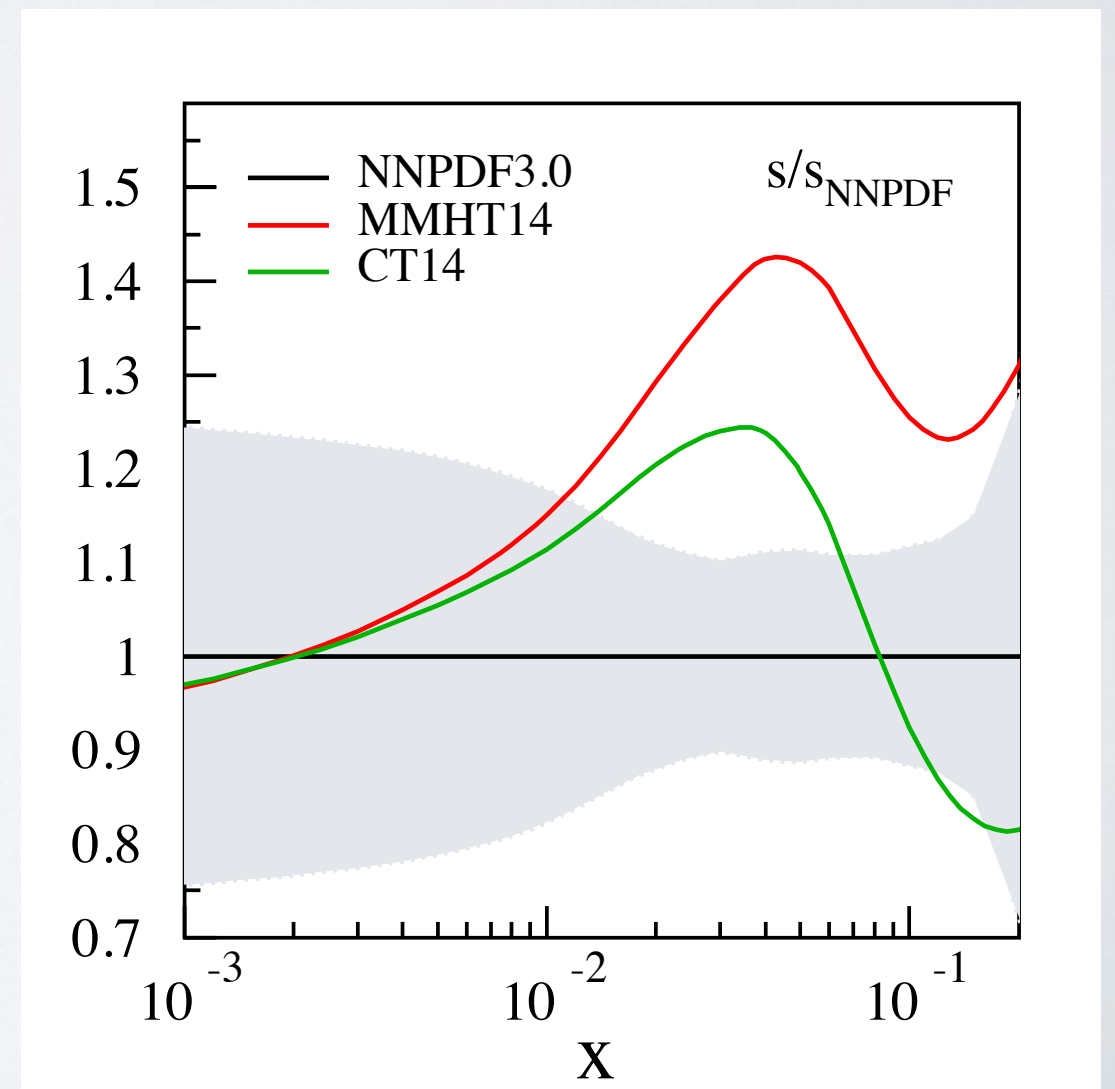
are PDFs that good?



$$\chi_{\text{MMHT14}}^2 = 1271.7$$

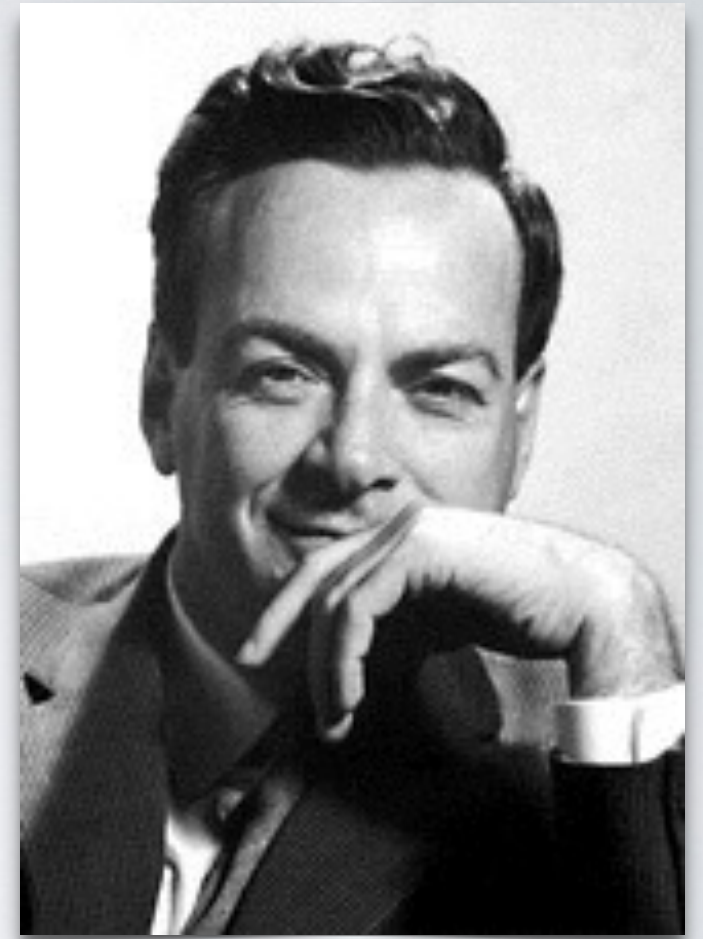
$$\chi_{\text{CT14}}^2 = 1185.3$$

$$\chi_{\text{NNPDF3.0}}^2 = 1017.2$$

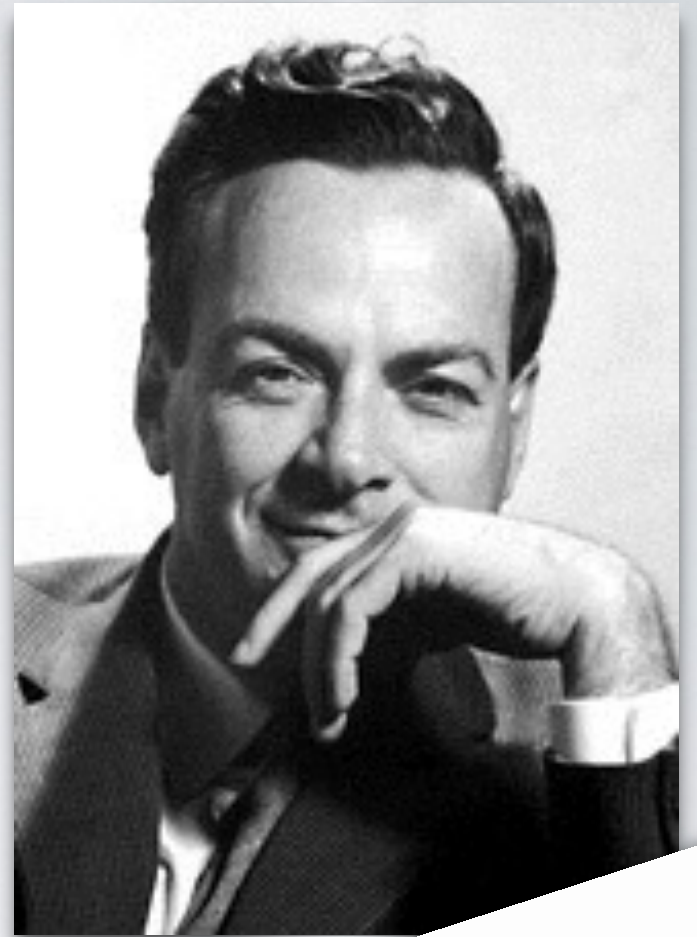


combined PDFs and FFs extraction

combined PDFs and FFs extraction



combined PDFs and FFs extraction



MAY 1977

VOLUME 15, NUMBER 9
of high-transyPHYSICAL REVIEW D
Quark elastic

REVIEW D
Quark elastic scattering as a source of high-transverse-momentum mesons*
R. D. Field and R. P. Feynman
California Institute of Technology, Pasadena, California 91125
(Received 20 October 1976)

REVIEW D

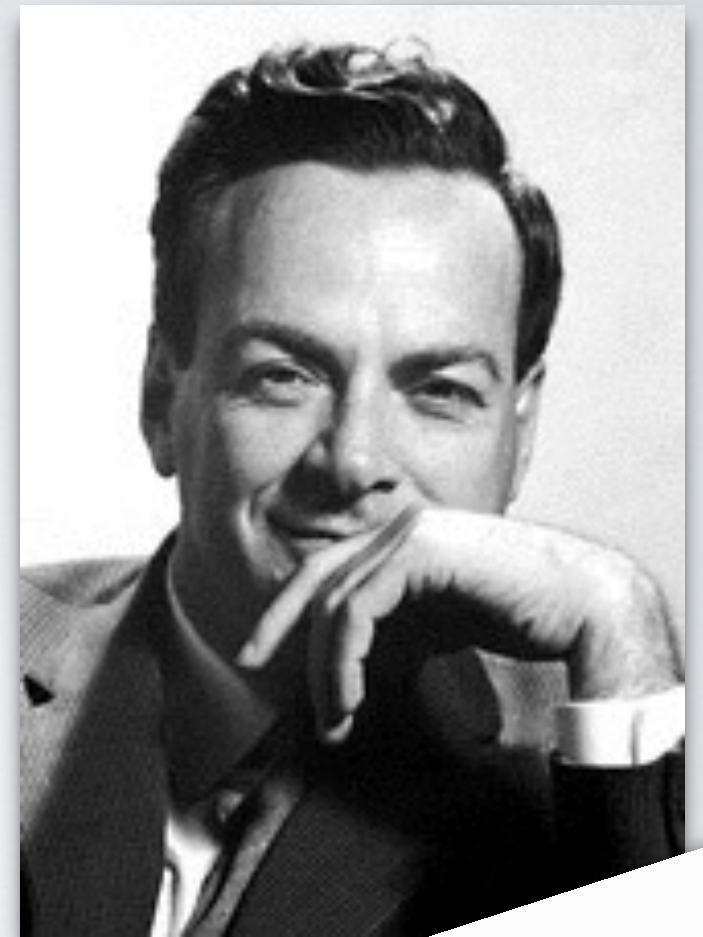
Quark elastic scattering as a source of high-transverse-momentum particles

R. D. Field and R. P. Feynman
California Institute of Technology, Pasadena, California 91225
(Received 20 October 1976)

We investigate the consequences of the assumption that the high-transverse-momentum particles seen in hadron-hadron collisions are produced by a single, hard, large-angle elastic scattering of quarks, one from the target and one from the beam. The fast outgoing quarks are assumed to fragment into a cascade of hadrons. The distributions of quarks in the incoming hadrons are determined from lepton-hadron data, together with certain theoretical constraints such as sum rules, etc. The manner in which quarks cascade into hadrons is determined from particle arguments. The quark elastic scattering cross section is supplemented in a purely phenomenological way and the choice $d\sigma/d\hat{T} = 2.3 \times 10^4 / (-\hat{T})^2$ mb GeV⁴ is used. It is shown that all the data for hadron-hadron collisions are predicted and described sensitively on the exact form for $d\sigma/d\hat{T}$ and therefore test the quark model. The predicted distributions for p^+ , p^- , K^+ , K^- , and π are predicted and described by beams of π^+ and protons on a proton target. The predicted distributions for p^+ , p^- , K^+ , K^- , and π are predicted and described by beams of π^+ and protons on a proton target. The predicted distributions for p^+ , p^- , K^+ , K^- , and π are predicted and described by beams of π^+ and protons on a proton target.

combined PDFs and FFs extraction

number/type data



1 MAY 1977

VOLUME 15, NUMBER 9
of high-transyPHYSICAL REVIEW D
Quark elasti

REVIEW D

Quark elastic scattering as a source of high-transverse-momentum mesons*

R. D. Field and R. P. Feynman
California Institute of Technology, Pasadena, California 91125
(Received 20 October 1976)

the assumption that the high-transverse-momentum particles are produced by a single, hard, large-angle elastic scattering of quarks in the beam. The fast outgoing quarks are then assumed to produce mesons together with certain other particles in a cascade interaction.

VIEW D

mark elastic scattering as a source of high-energy

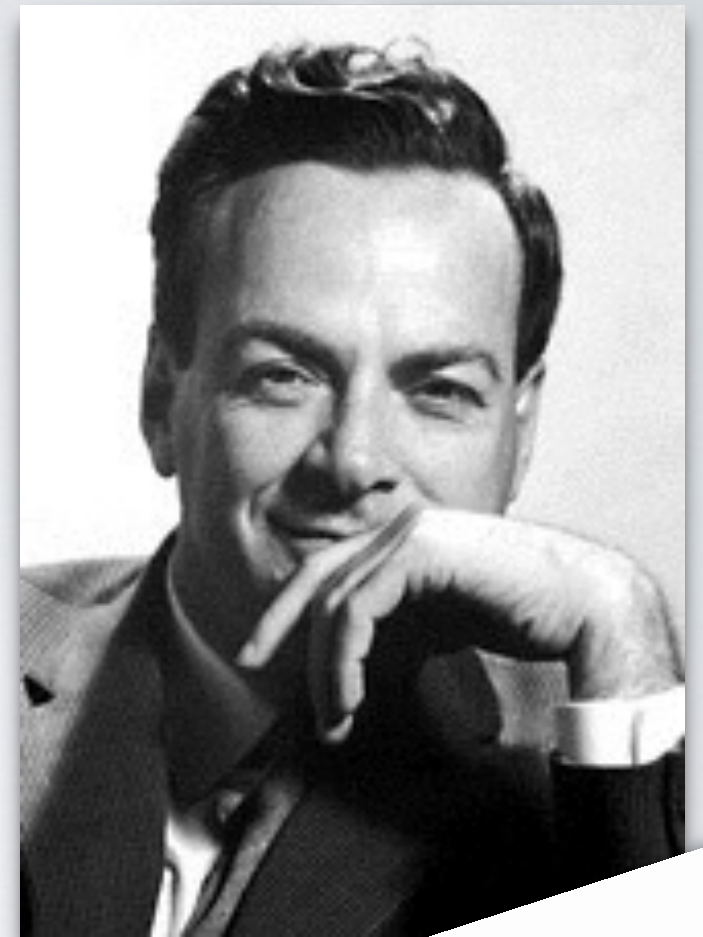
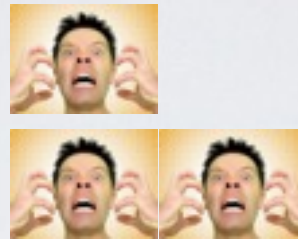
R. D. Field and R. P. Feynman
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We investigate the consequences of the assumption that the high-transverse-momentum particles seen in hadron-hadron collisions are produced by a single, hard, large-angle elastic scattering of quarks, one from the target and one from the beam. The fast outgoing quarks are assumed to fragment into a cascade of hadrons. The distributions of quarks in the incoming hadrons are determined from lepton-hadron inelastic scattering data, together with certain theoretical constraints such as sum rules, etc. The manner in which quarks cascade into hadrons is determined from particle distributions seen in lepton-hadron and lepton-lepton collisions. It is supplemented in a purely phenomenological way and the choice $d\sigma/d\hat{T} = 2.3 \times 10^5 / (-\hat{T})^2$ mb GeV⁴ is used. It is shown that all the data for hadron-hadron collisions can be described sensitively on the exact form for $d\sigma/d\hat{T}$ and therefore test the quark model. The model predicts single-particle production in $p\bar{p}$ collisions and distributions for beams of π^+ , π^- , K^+ , K^- , and \bar{K}^0 are predicted and compared with data, but the model is inconsistent with data, but the model is presented that

combined PDFs and FFs extraction

number/type data

number parameter/unknowns

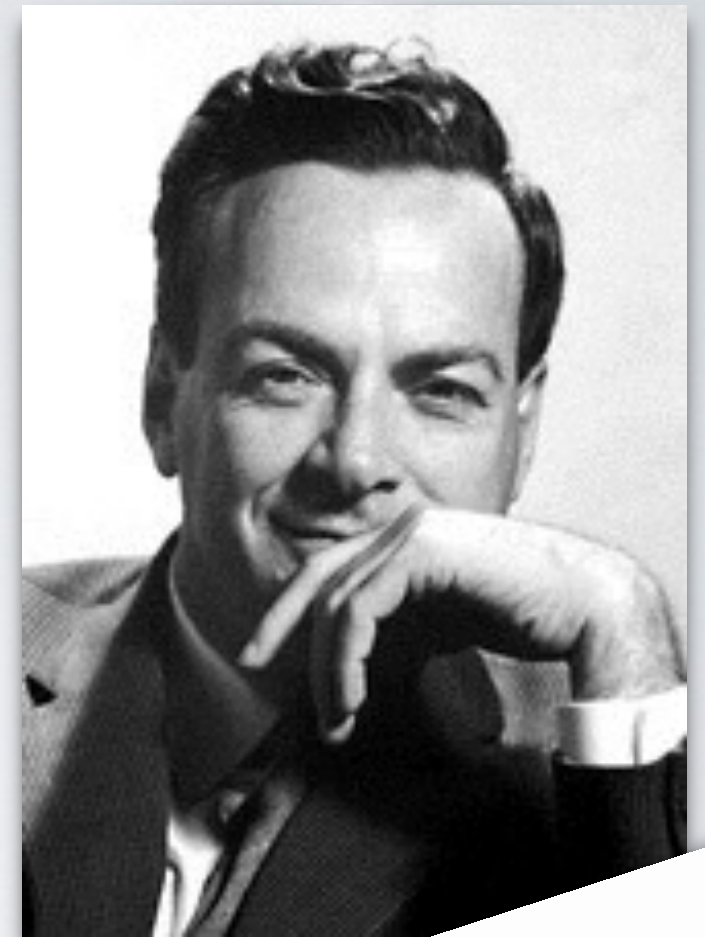
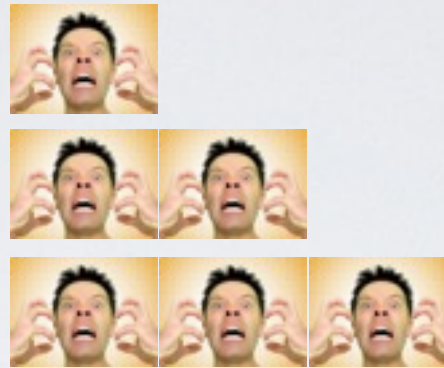


combined PDFs and FFs extraction

number/type data

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topography



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the assumption that the high-transverse-momentum particles are produced by a single, hard, large-angle quark scattering in the beam. The fast outgoing quarks are then accompanied by a cascade of quarks and gluons, which together with certain mesons and baryons form the observed particles.

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VOLUME 1

mark elastic scattering as a source of high- p_T particles

R. D. Field and R. P. Feynman
California Institute of Technology, Pasadena, California 91125
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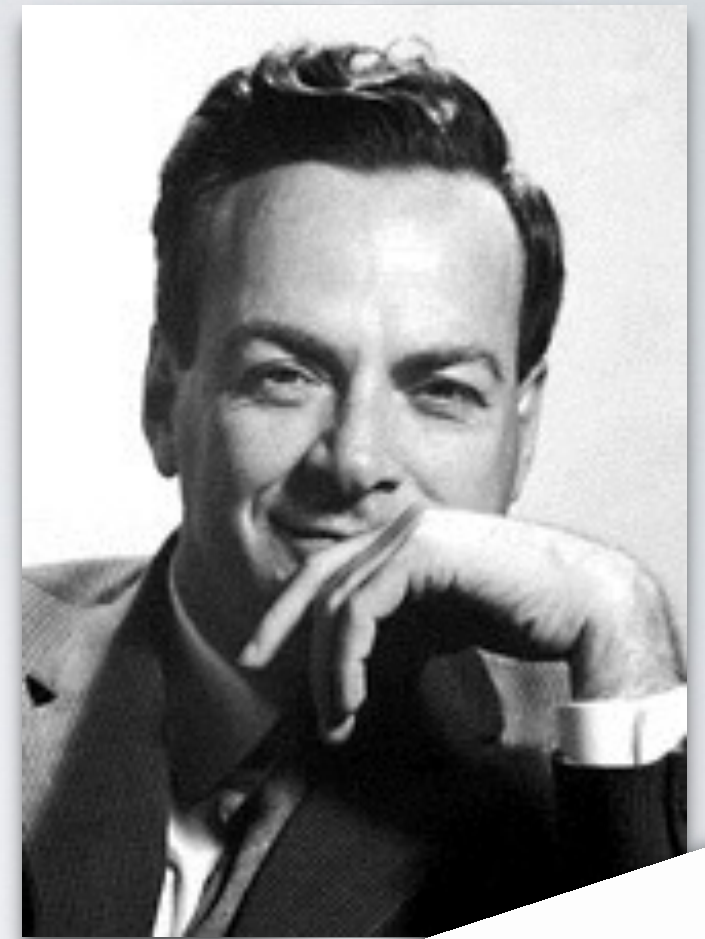
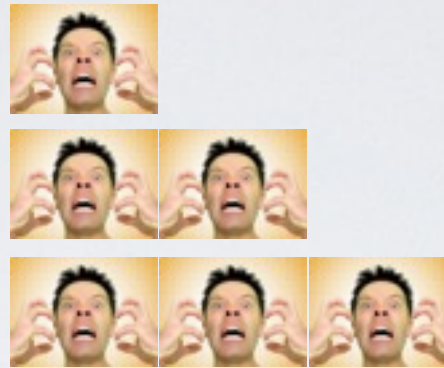
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combined PDFs and FFs extraction

number/type data

number parameter/unknowns

topography



reweighting:

PHYSICAL REVIEW D

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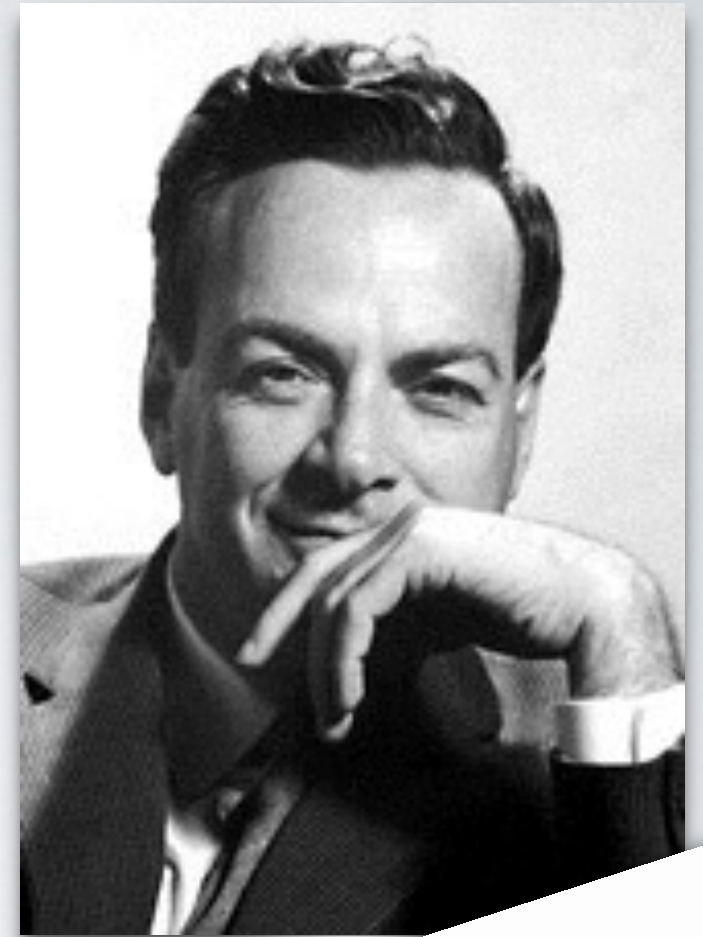
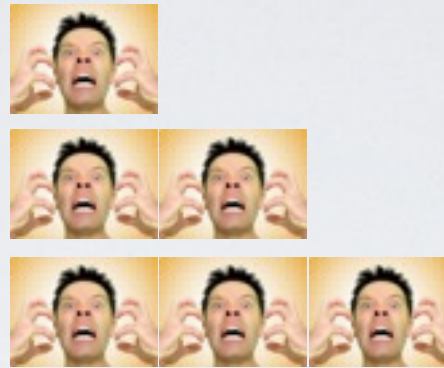
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combined PDFs and FFs extraction

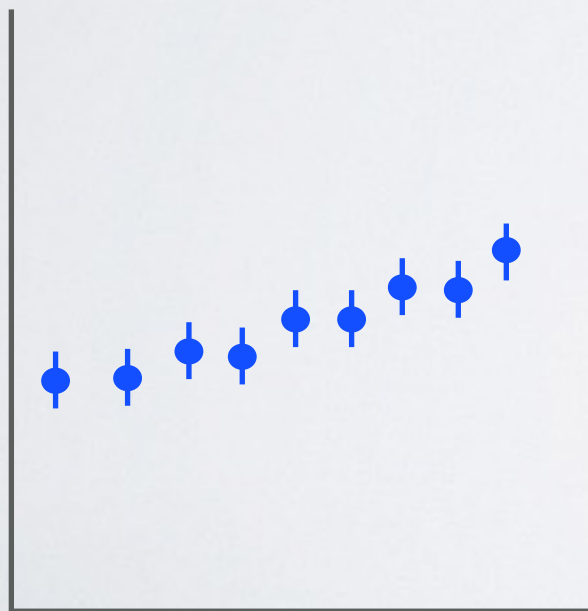
number/type data

number parameter/unknowns

topography



reweighting:

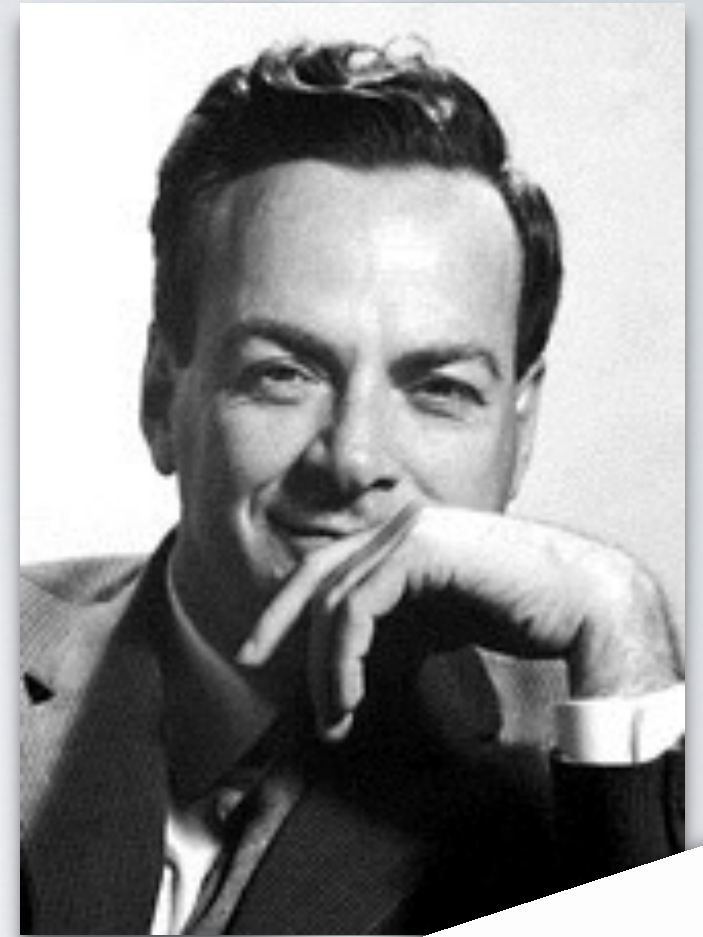
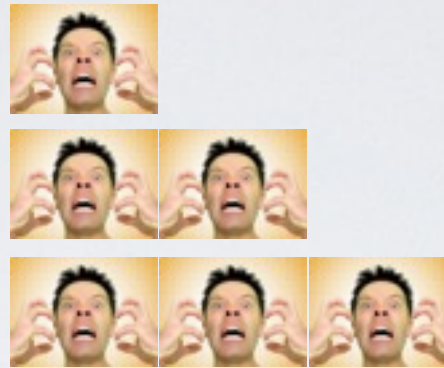


combined PDFs and FFs extraction

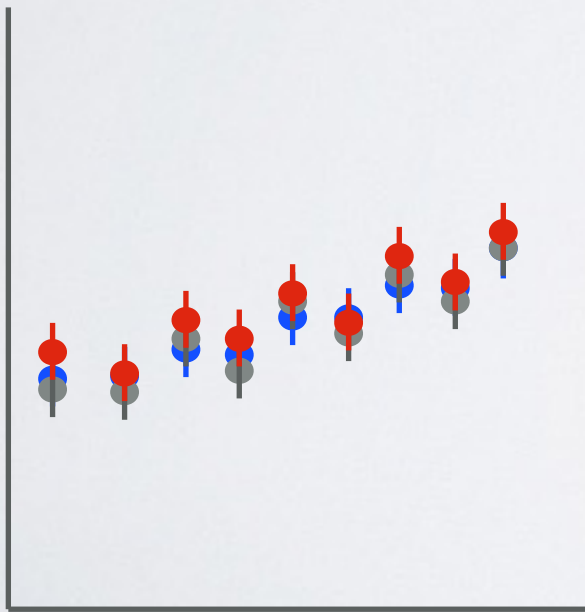
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topography



reweighting:

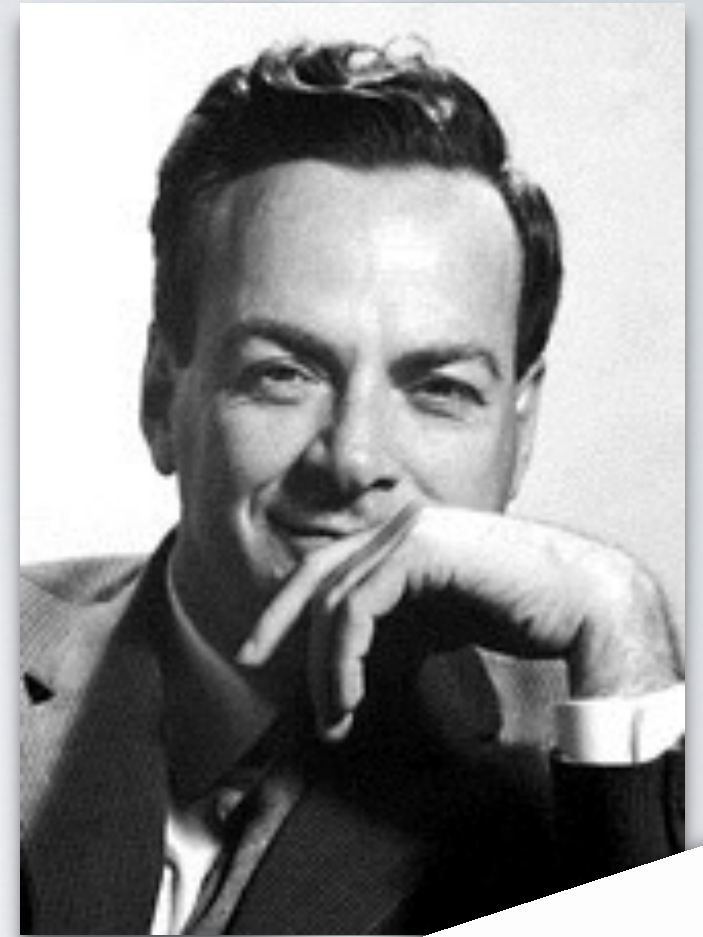
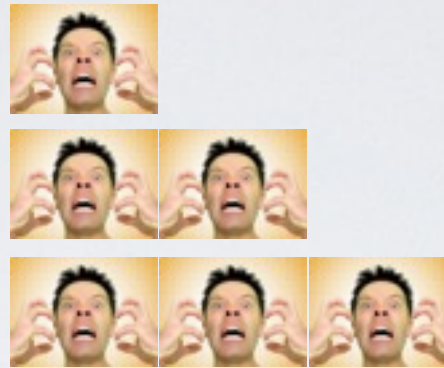


combined PDFs and FFs extraction

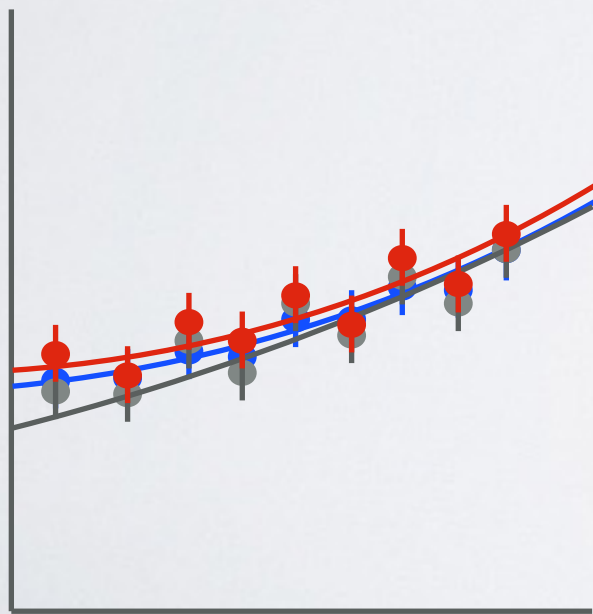
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topography



reweighting:

PHYSICAL REVIEW D
Quark elastiVOLUME 15, NUMBER 9
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mark elastic scattering as a source of high- p_T

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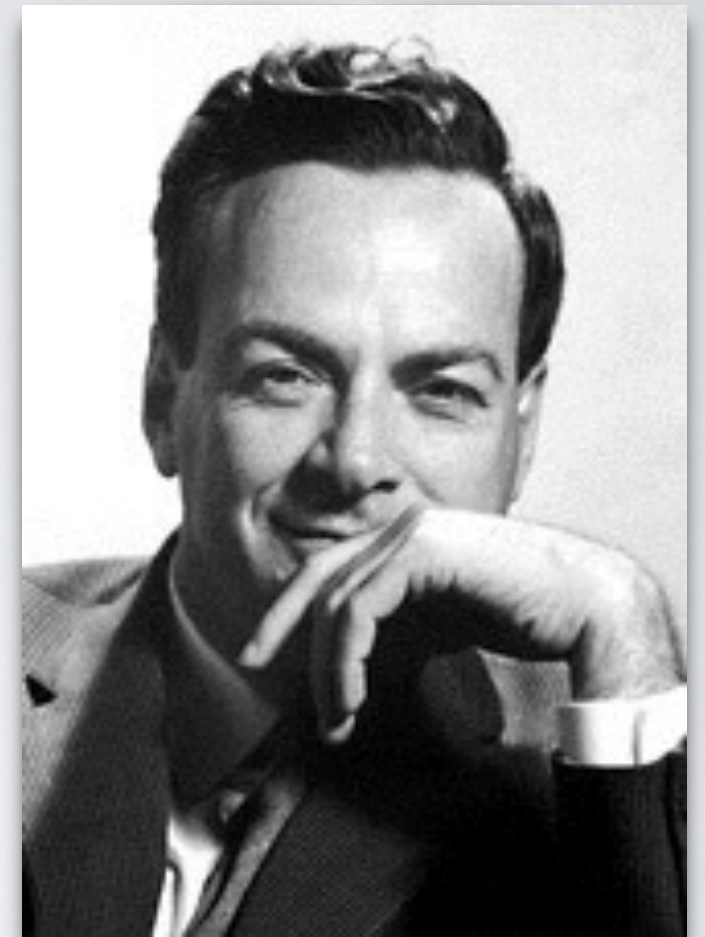
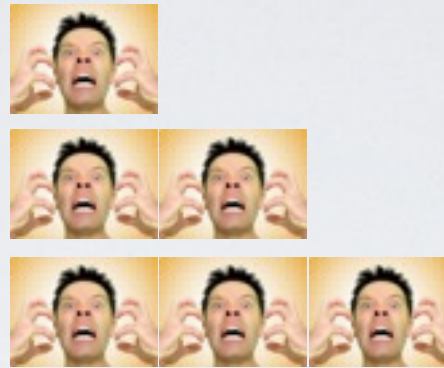
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combined PDFs and FFs extraction

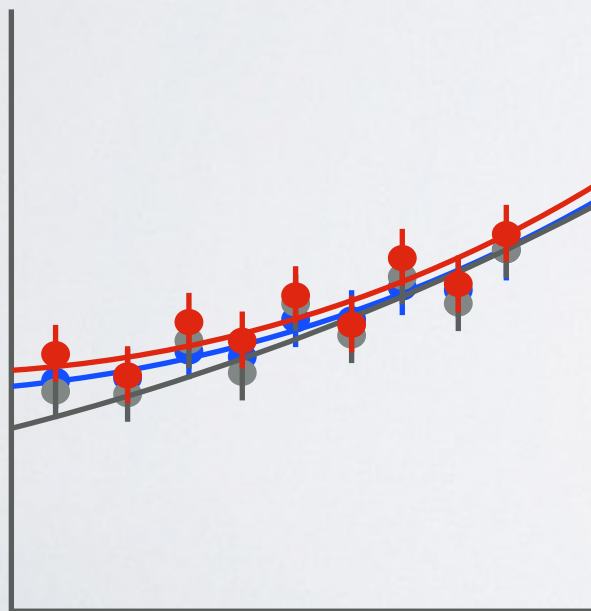
number/type data

number parameter/unknowns

topography



reweighting:



$$f_i(x)$$

$$f_i(x)$$

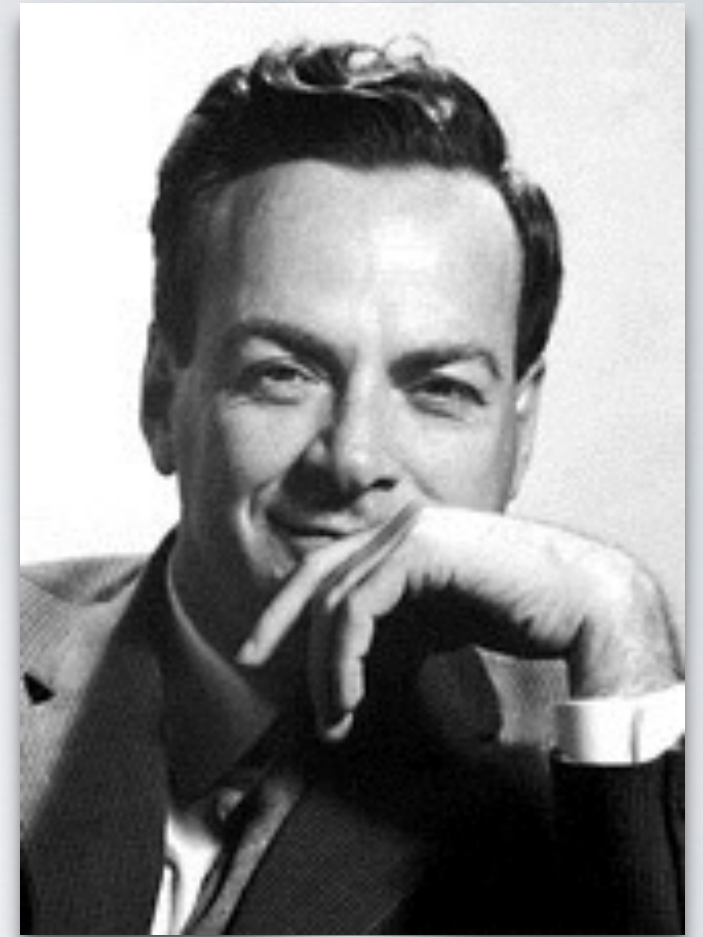
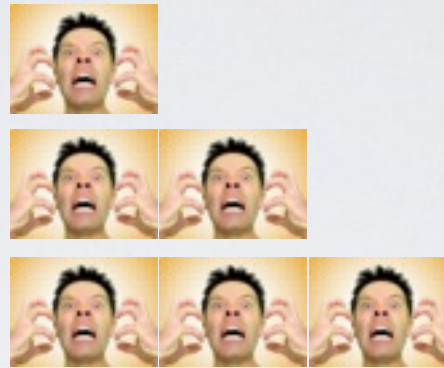
$$f_i(x)$$

combined PDFs and FFs extraction

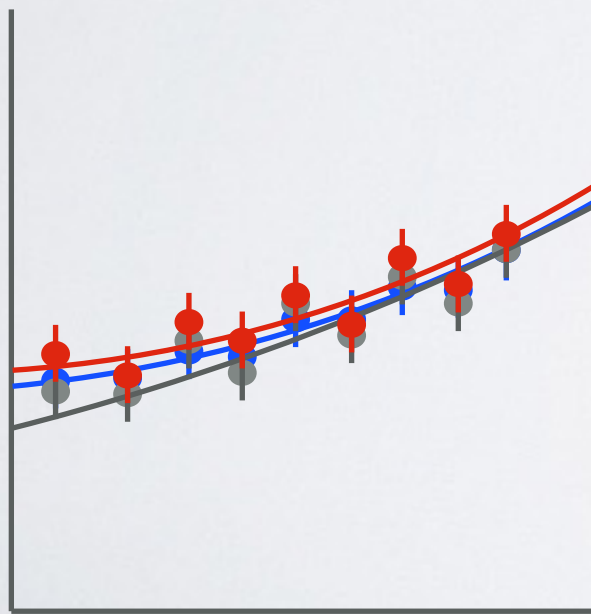
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reweighting:



$$f_i(x)$$

$$f_i(x)$$

$$f_i(x)$$

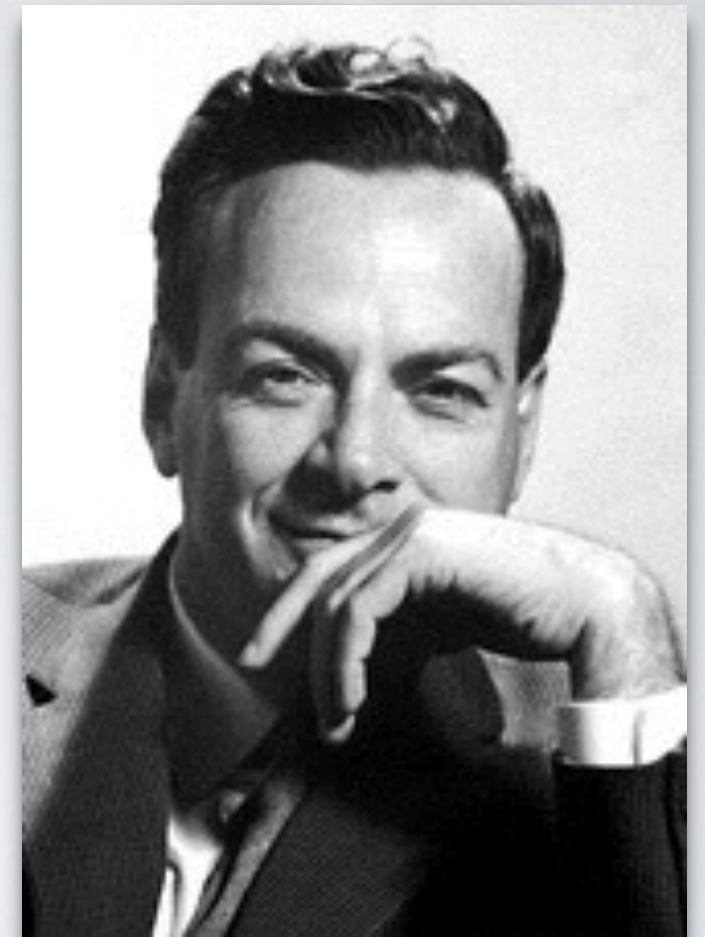
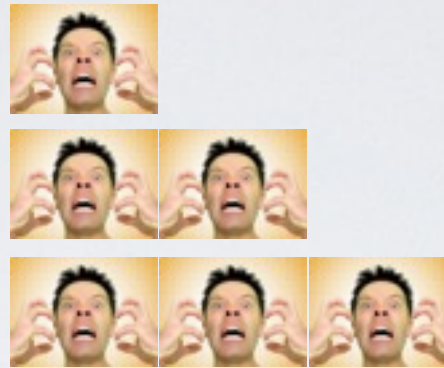
$$f_i^{best}(x) = \frac{1}{N_{rep}} \sum f_i(x)$$

combined PDFs and FFs extraction

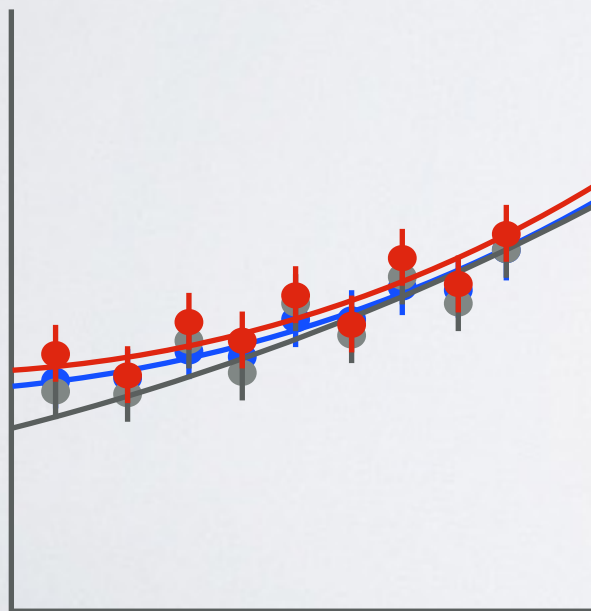
number/type data

number parameter/unknowns

topography



reweighting:



$$\begin{array}{ll} f_i(x) & w(\chi^2) \\ f_i(x) & w(\chi^2) \\ f_i(x) & w(\chi^2) \end{array}$$

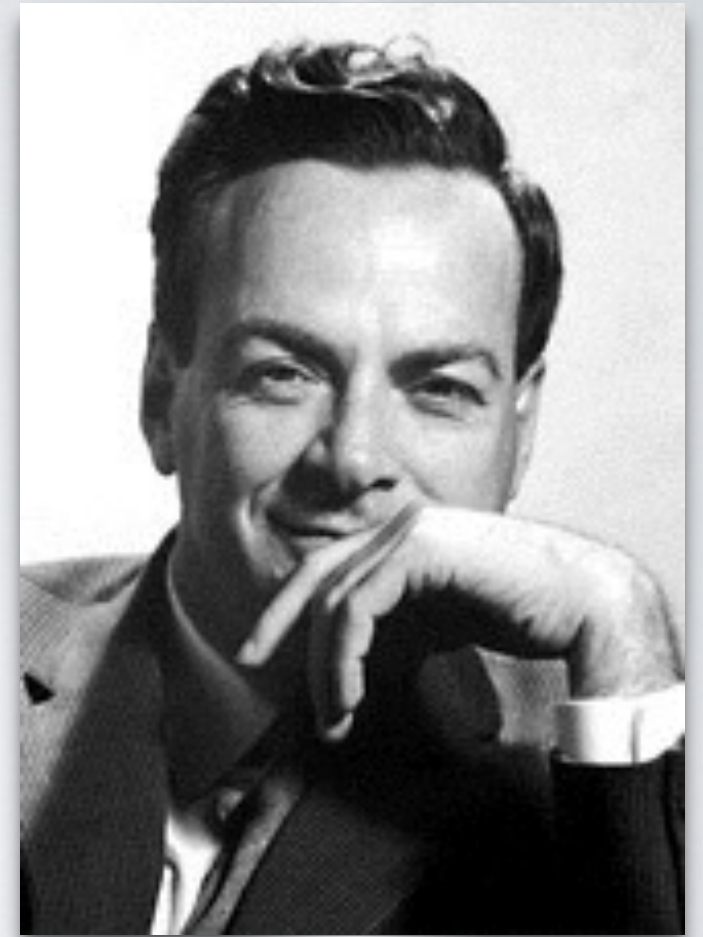
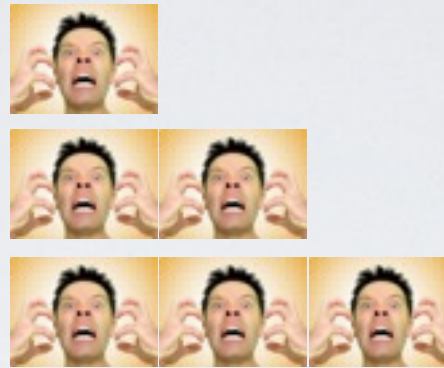
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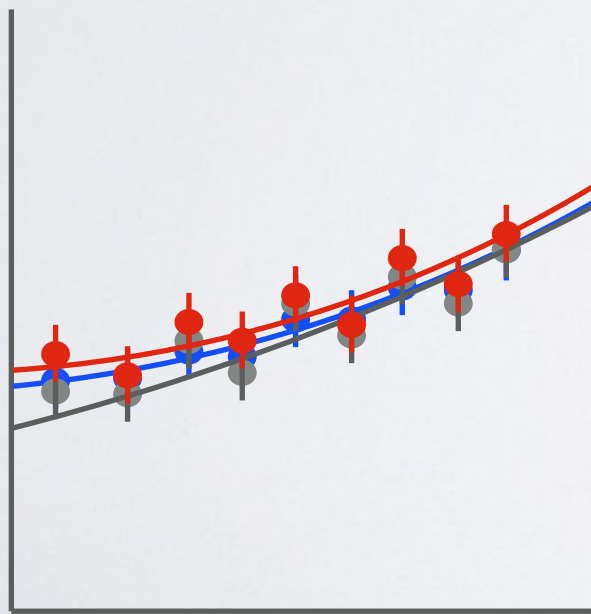
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reweighting:



$$f_i(x) \quad w(\chi^2)$$

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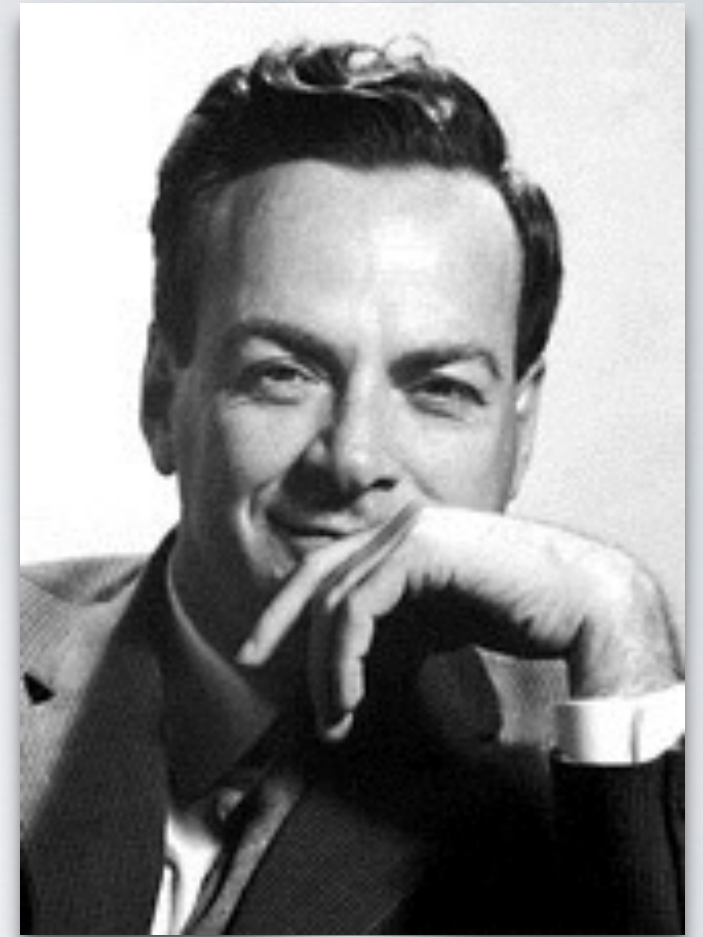
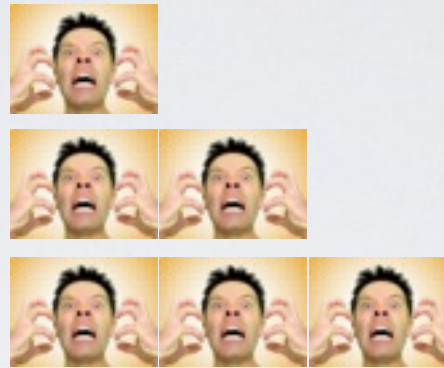
$$f_i^{reweight}(x) = \frac{1}{N_{rep}} \sum w f_i(x)$$

combined PDFs and FFs extraction

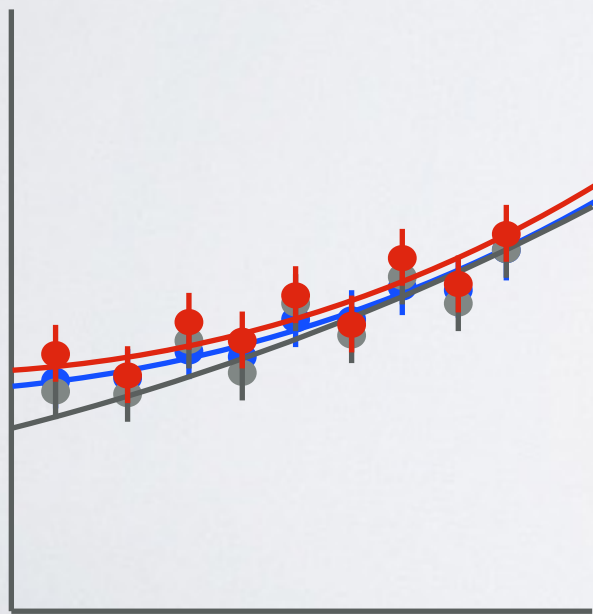
number/type data

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reweighting:



$$f_i(x) \quad w(\chi^2)$$

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$$\chi^2(\text{FFs})$$

$$f_i^{best}(x) = \frac{1}{N_{rep}} \sum f_i(x)$$

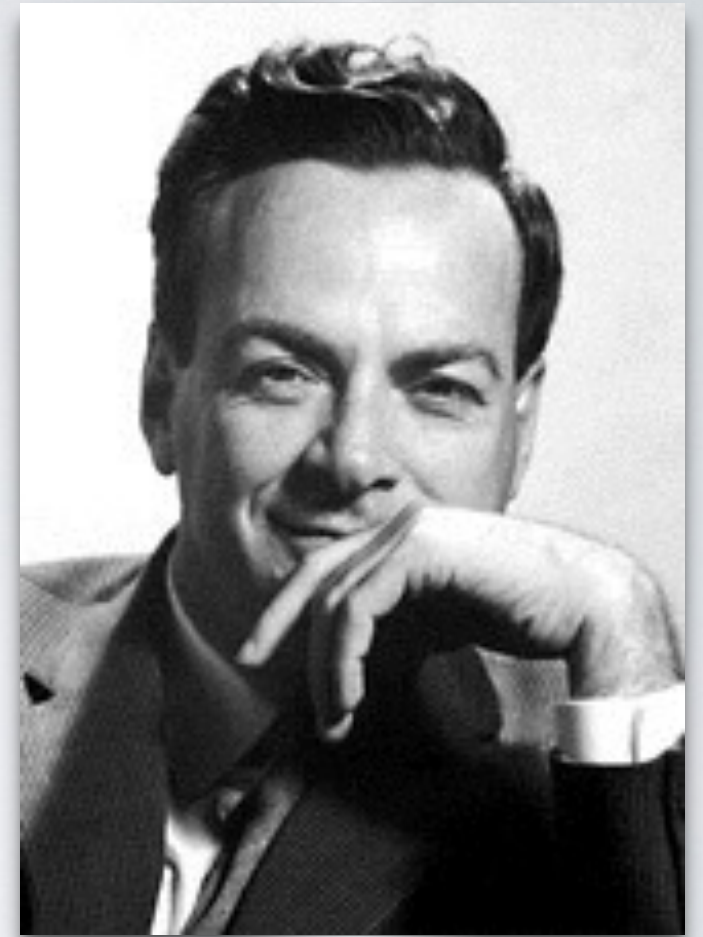
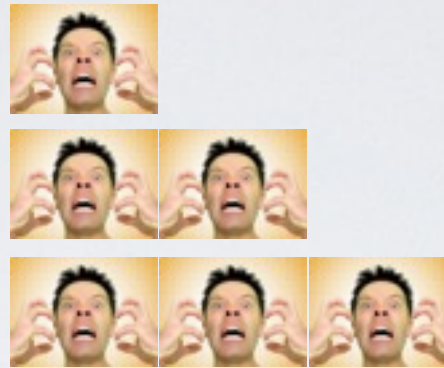
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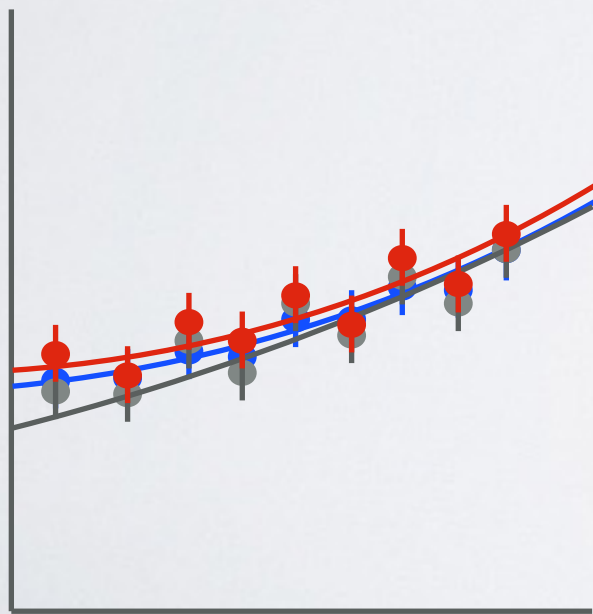
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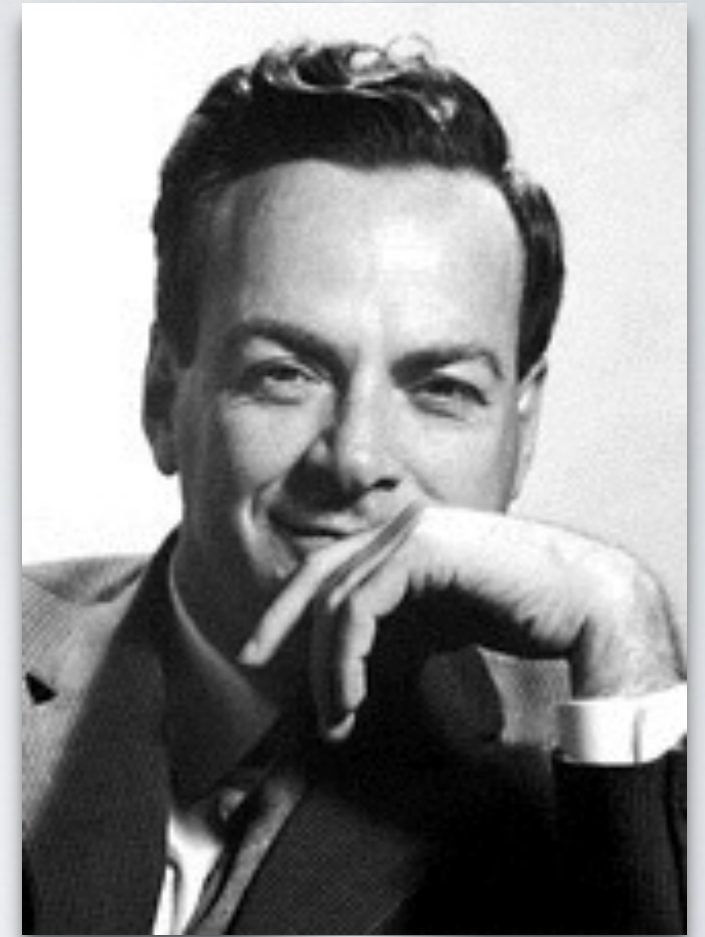
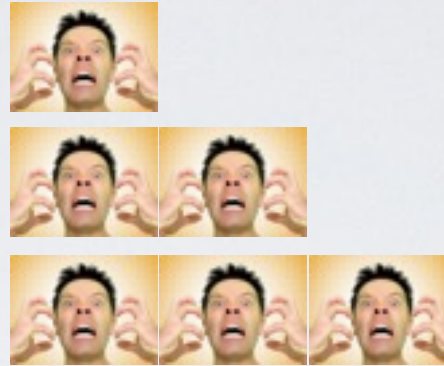
$$\chi^2(\text{FFs(PDFs)})$$

combined PDFs and FFs extraction

number/type data

number parameter/unknowns

topography



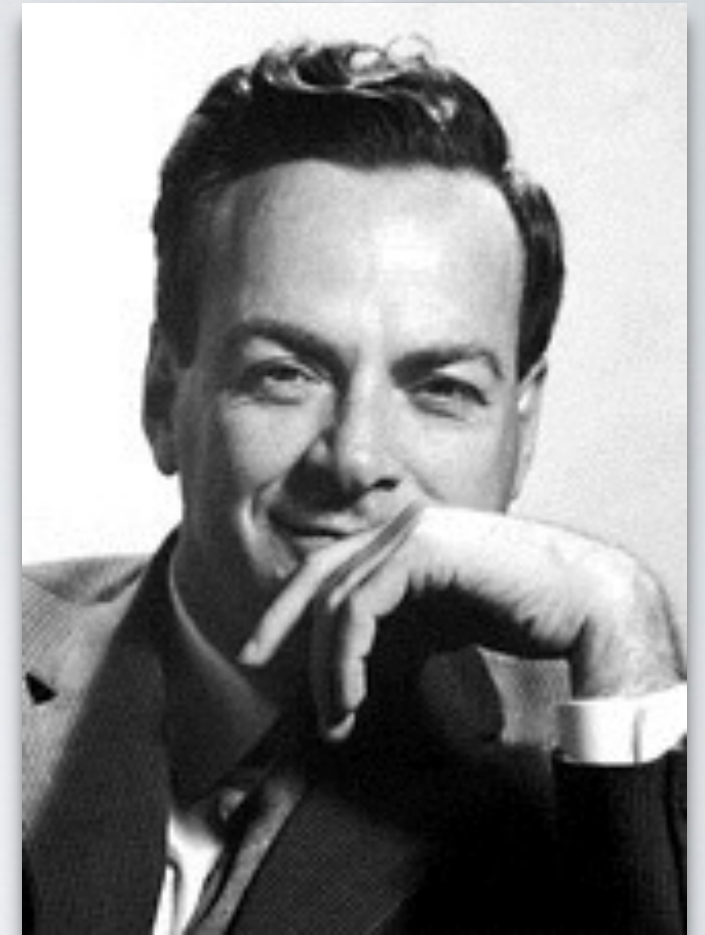
iterative FFs & PDFs determination:

combined PDFs and FFs extraction

number/type data

number parameter/unknowns

topography



iterative FFs & PDFs determination:

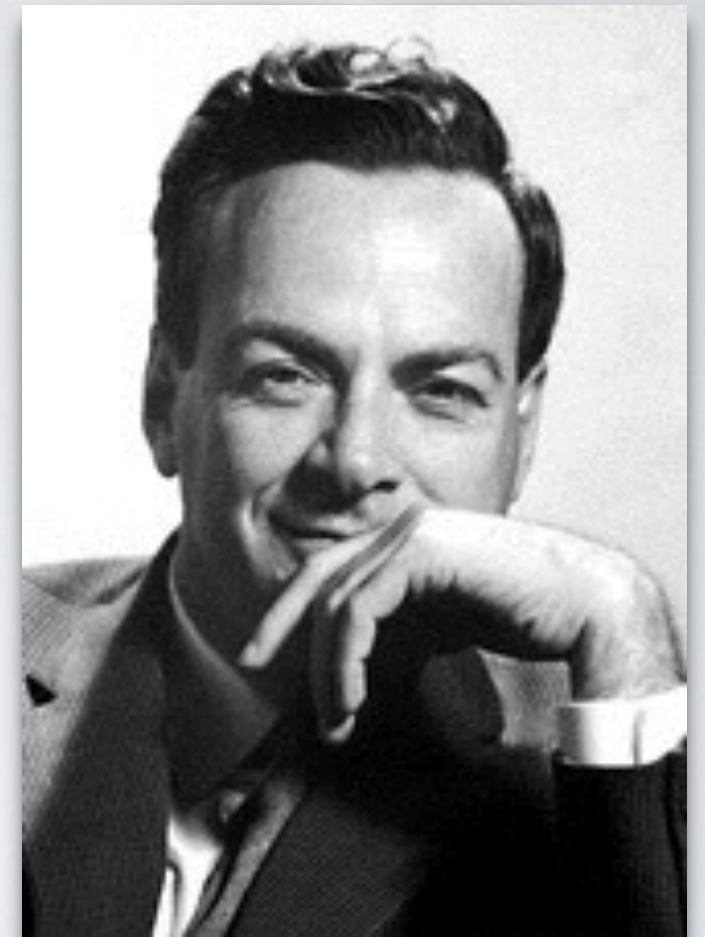
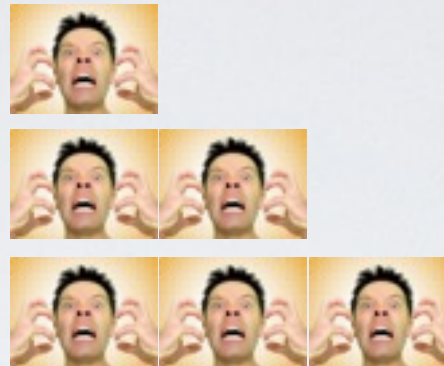
PDFs FFs

combined PDFs and FFs extraction

number/type data

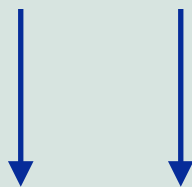
number parameter/unknowns

topography



iterative FFs & PDFs determination:

PDFs FFs



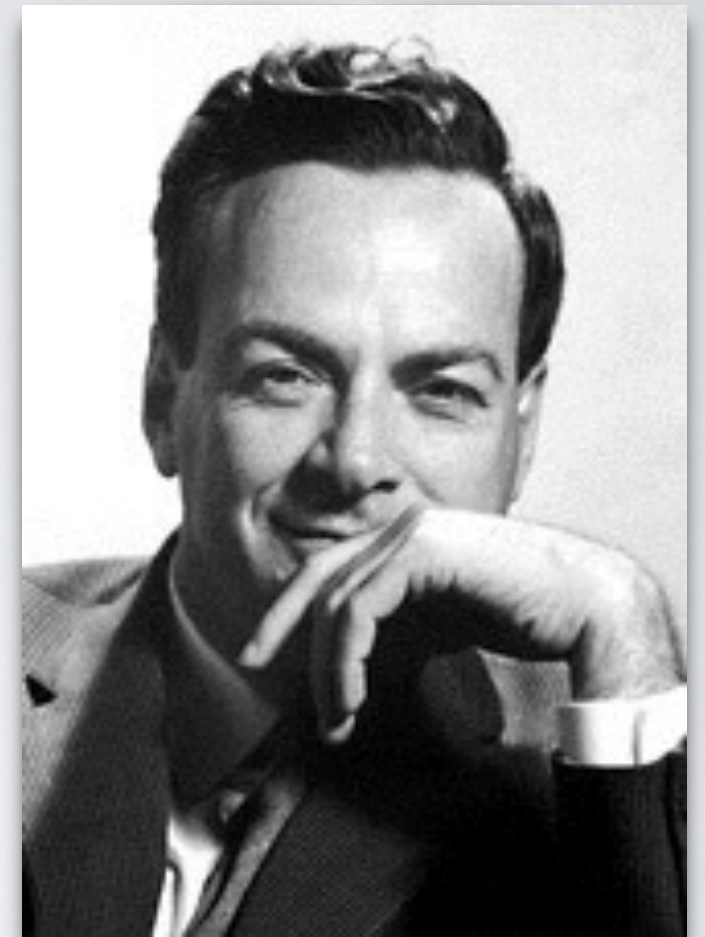
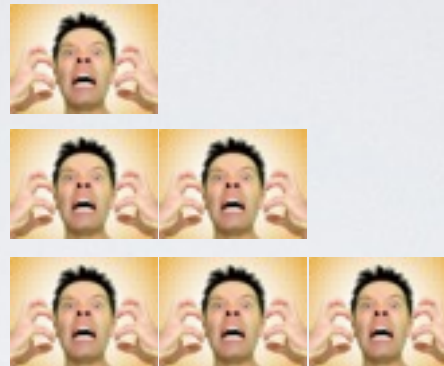
PDFs reweigh
with SIDIS

combined PDFs and FFs extraction

number/type data

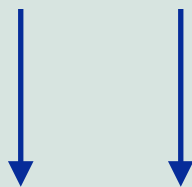
number parameter/unknowns

topography



iterative FFs & PDFs determination:

PDFs FFs



PDFs reweigh
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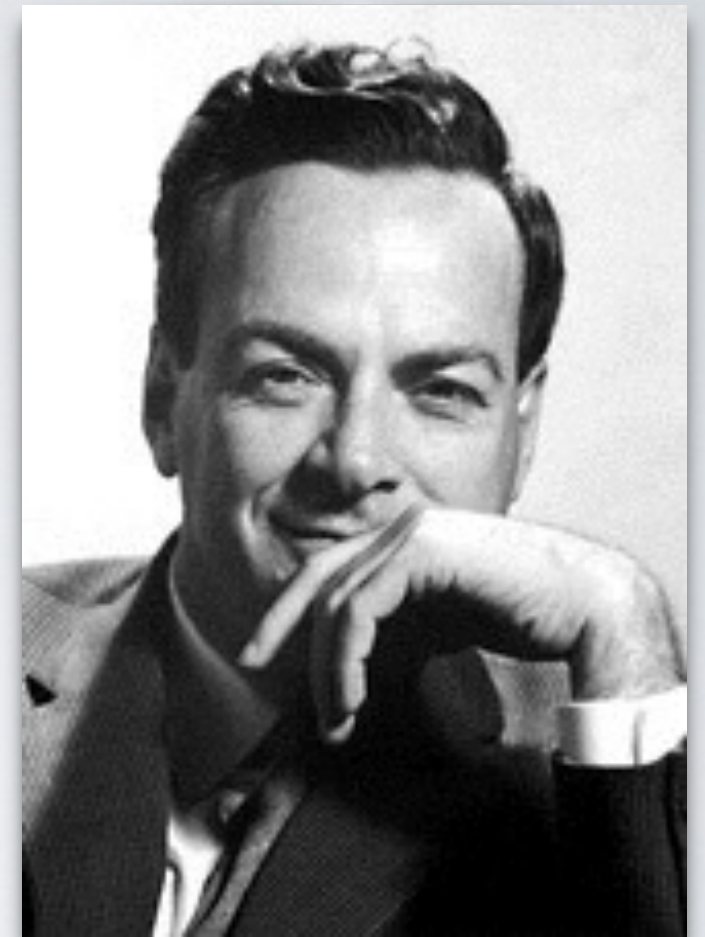
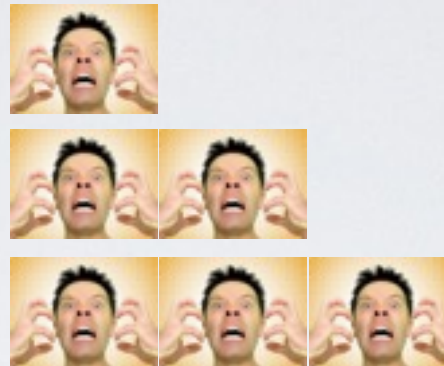
PDFs

combined PDFs and FFs extraction

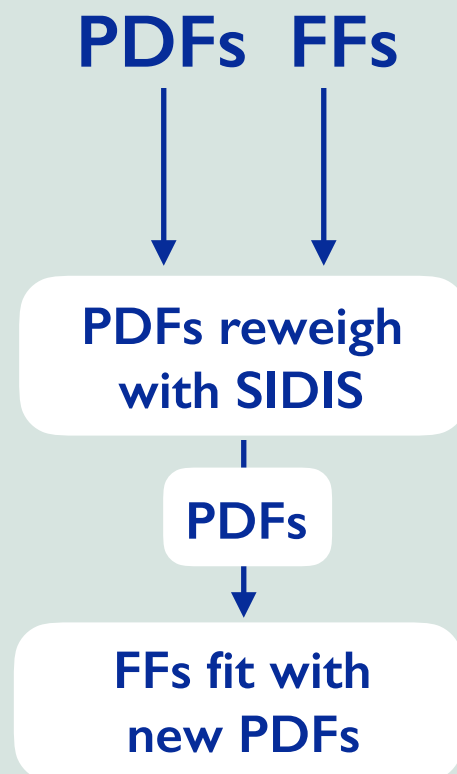
number/type data

number parameter/unknowns

topography



iterative FFs & PDFs determination:

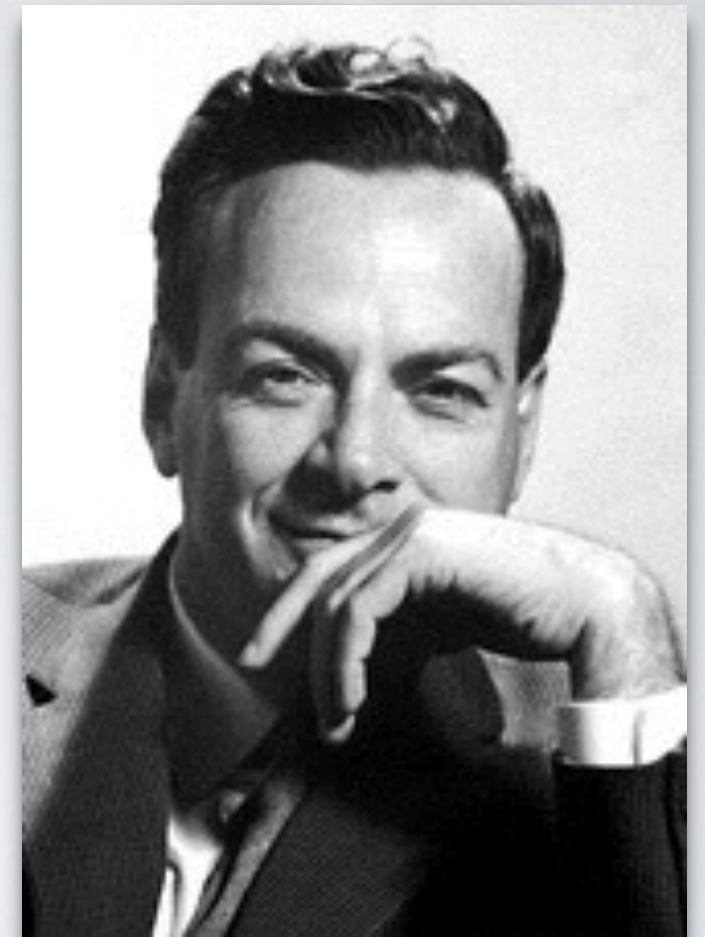
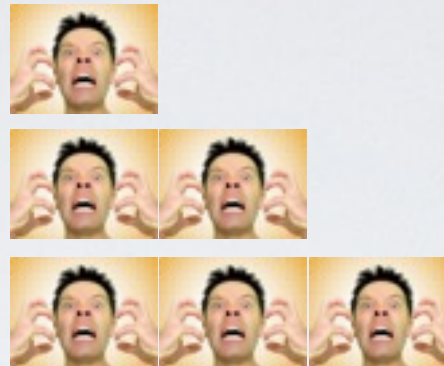


combined PDFs and FFs extraction

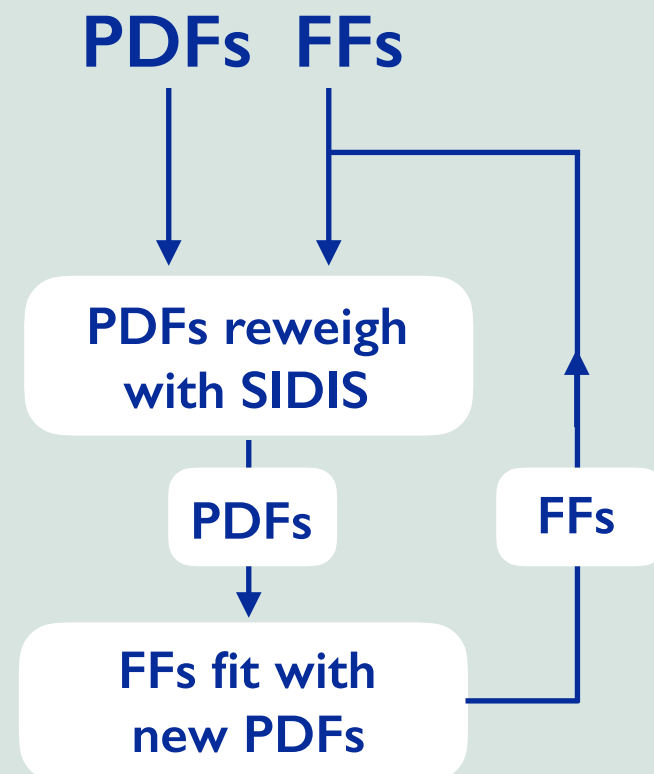
number/type data

number parameter/unknowns

topography



iterative FFs & PDFs determination:

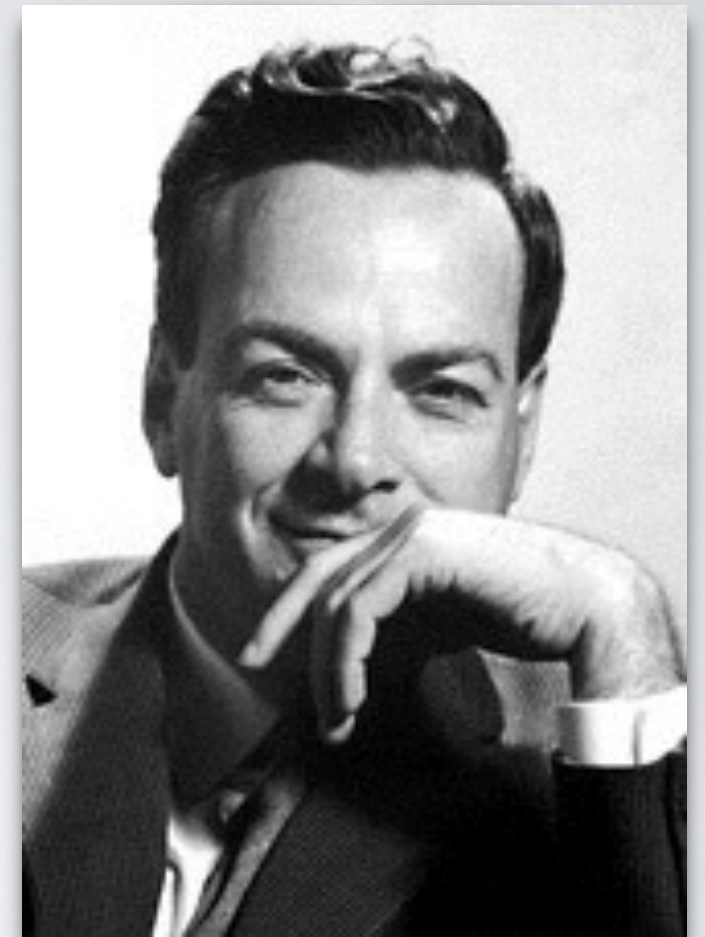
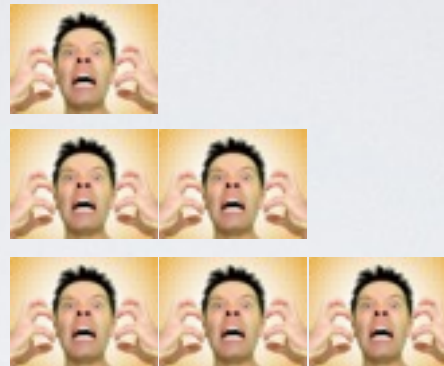


combined PDFs and FFs extraction

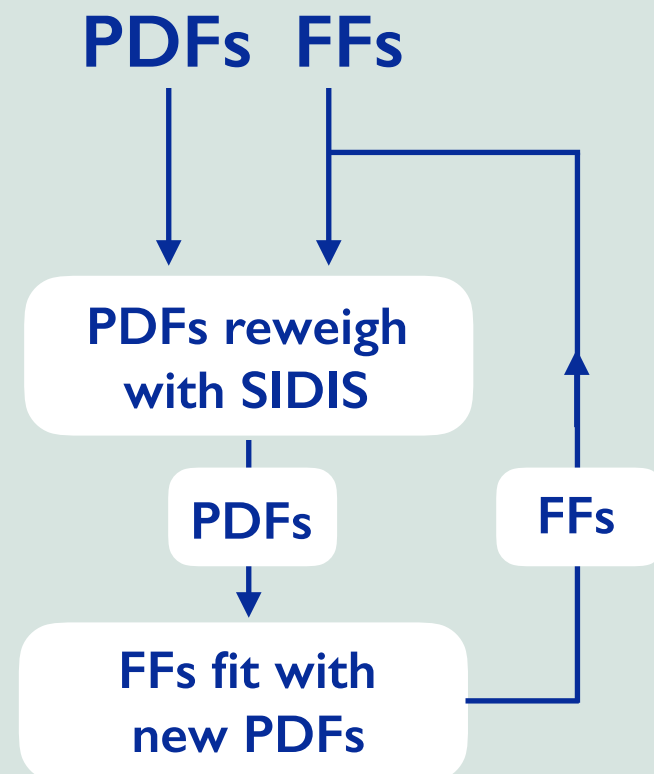
number/type data

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topography



iterative FFs & PDFs determination:



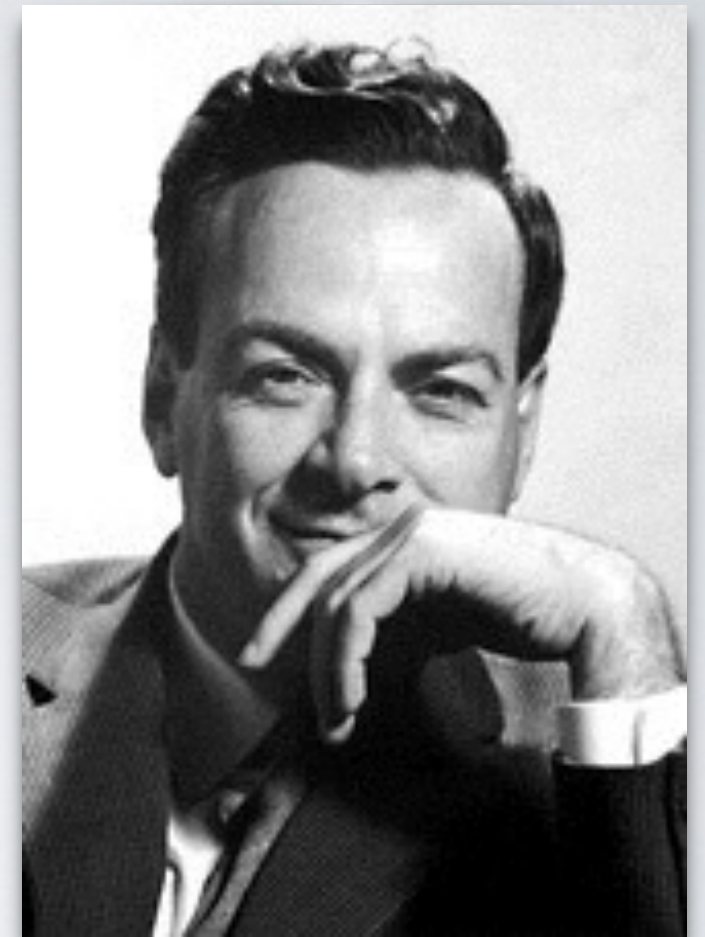
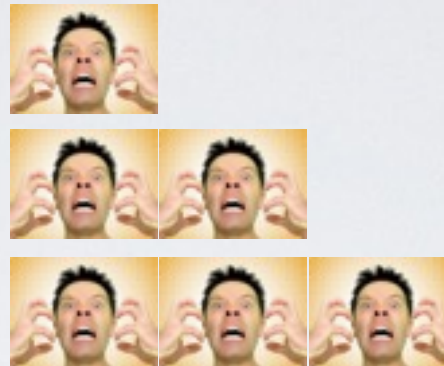
convergence?

combined PDFs and FFs extraction

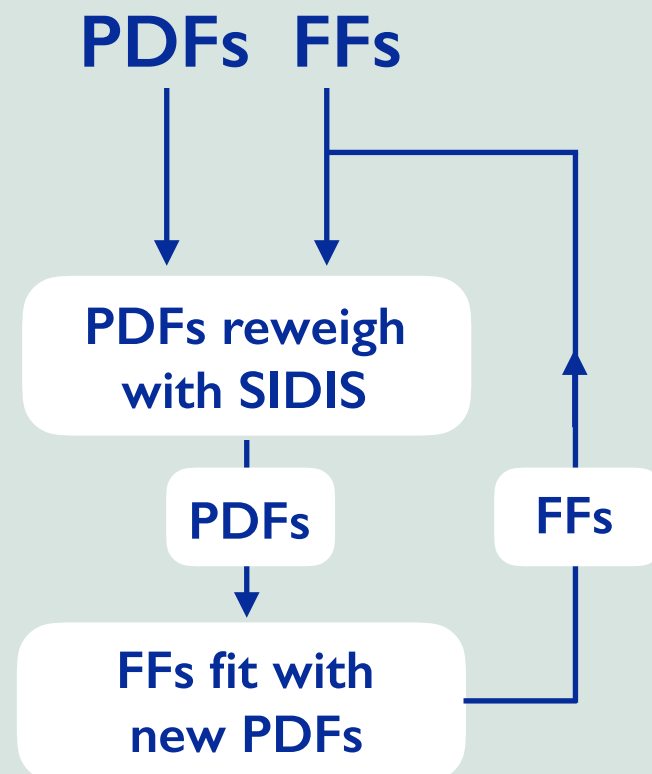
number/type data

number parameter/unknowns

topography



iterative FFs & PDFs determination:



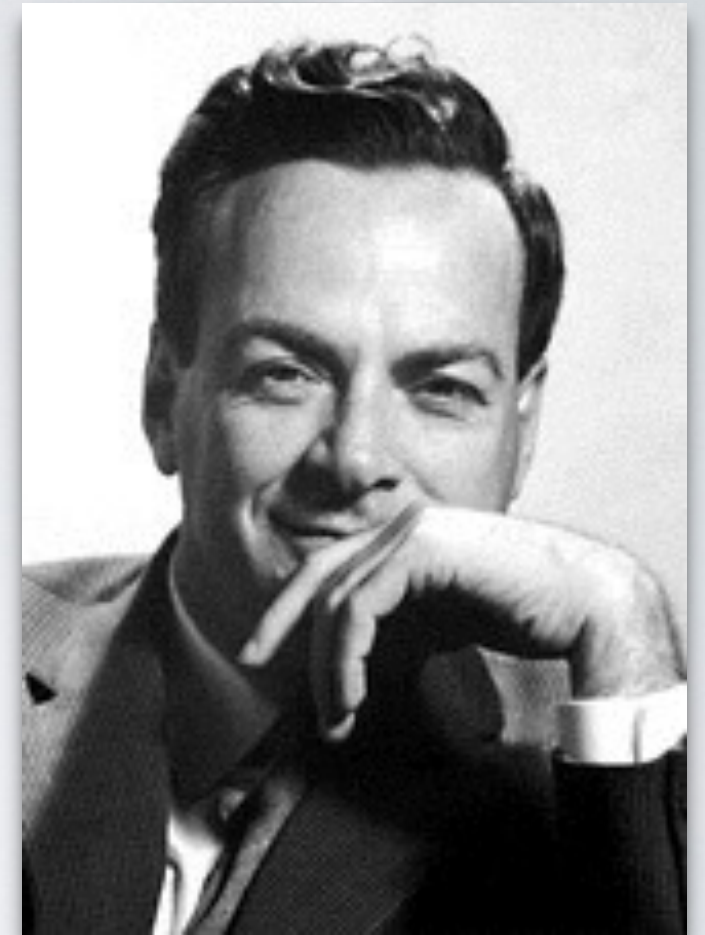
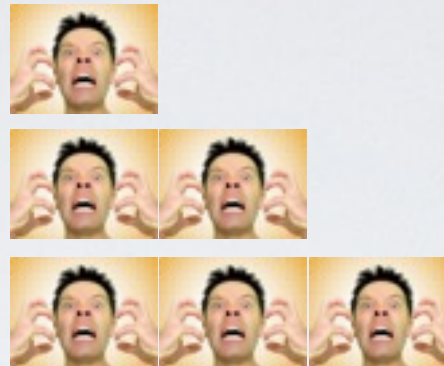
convergence?
and very fast!

combined PDFs and FFs extraction

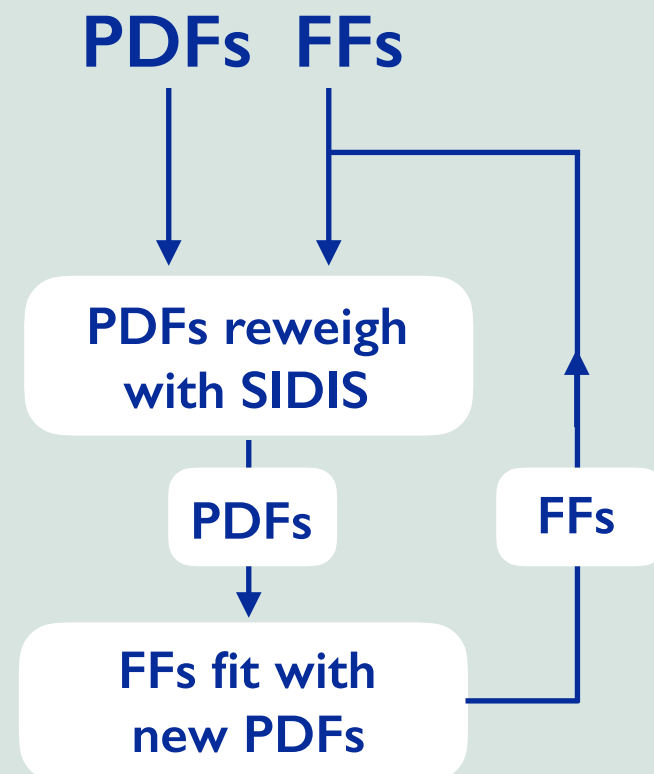
number/type data

number parameter/unknowns

topography

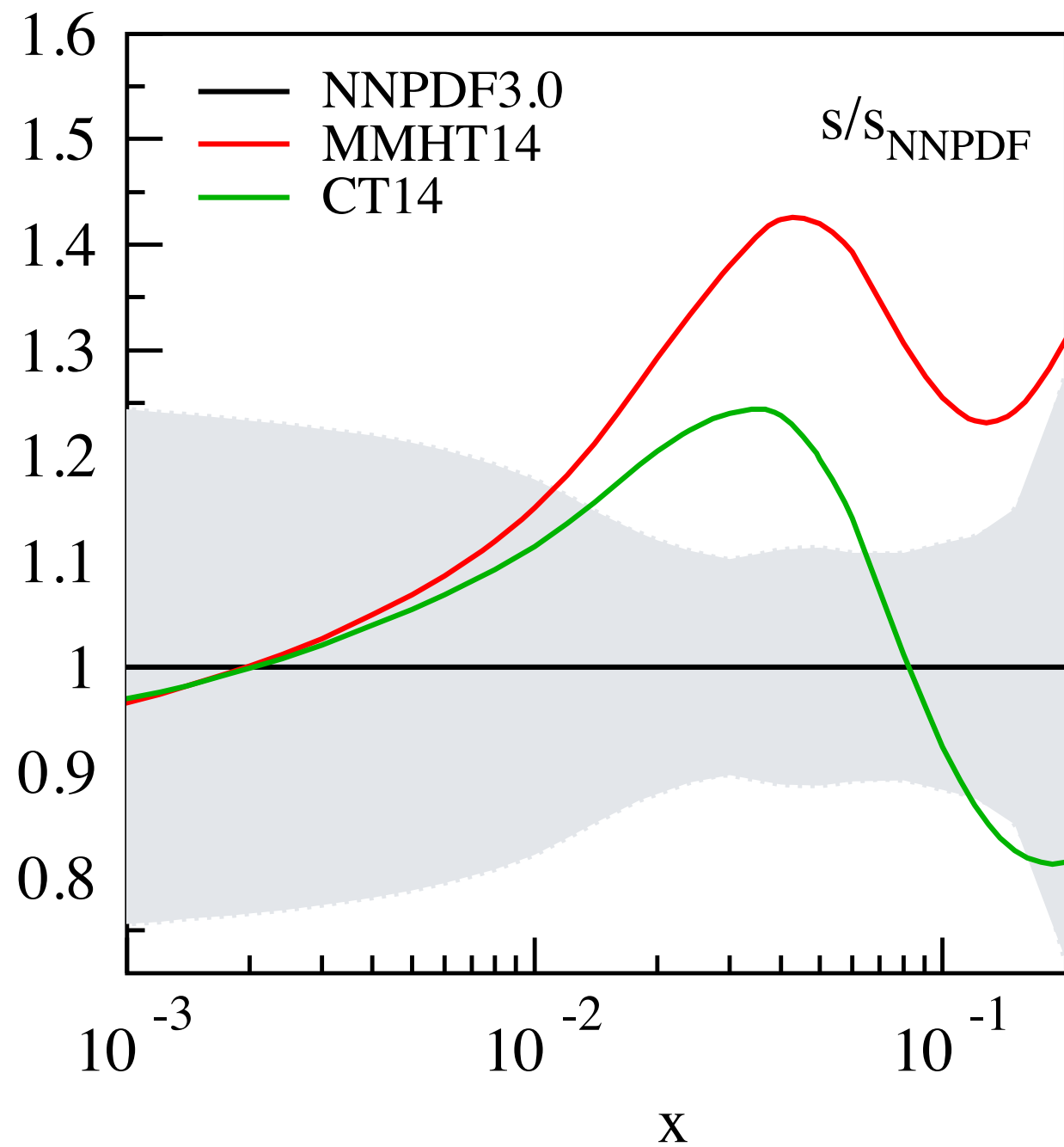


iterative FFs & PDFs determination:



convergence?
and very fast!
robust!

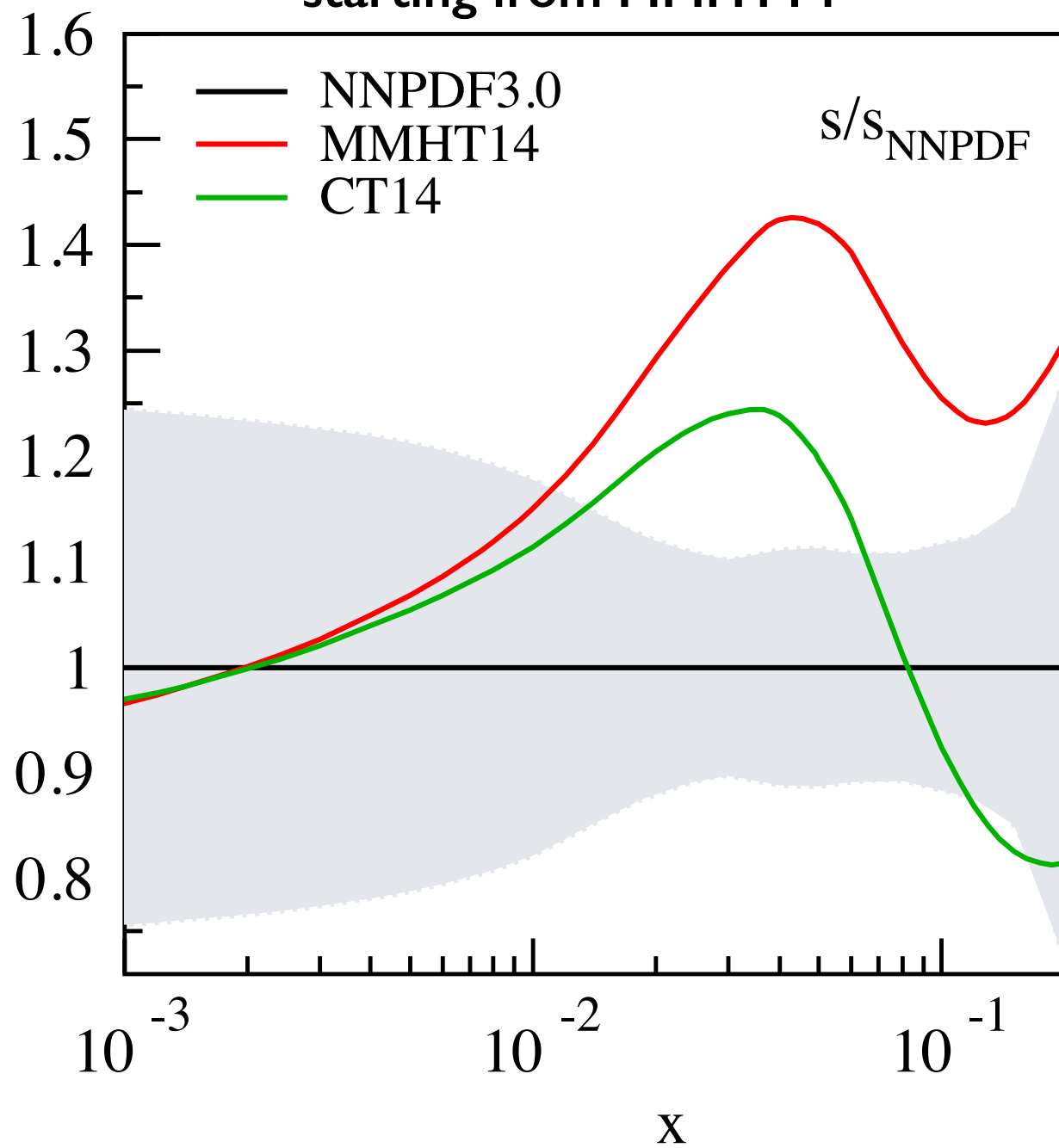
combined PDFs and FFs extraction



$$\chi^2_{FF} = 1271.7$$

combined PDFs and FFs extraction

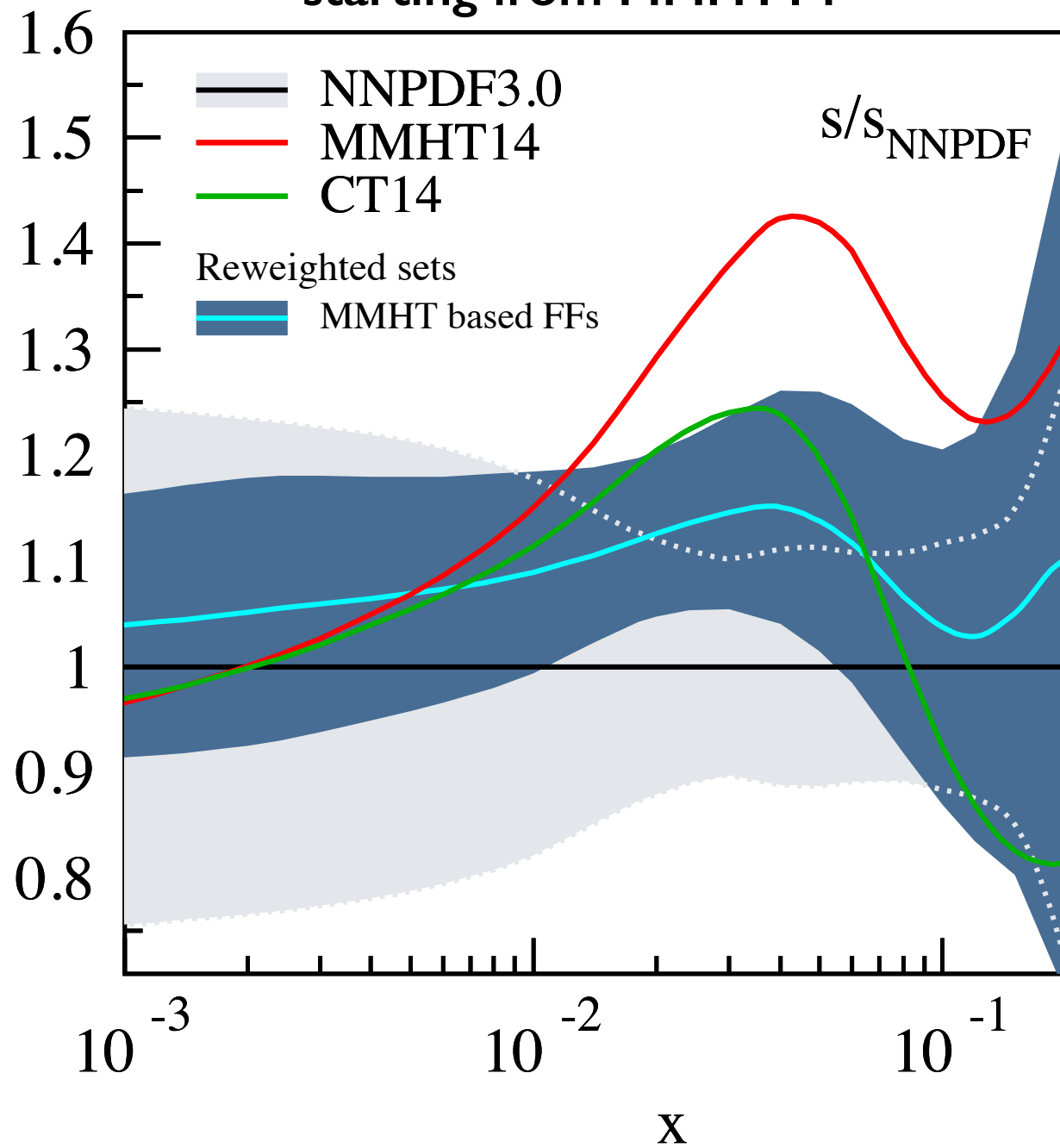
starting from MMHT14



$$\chi^2_{FF} = 1271.7$$

combined PDFs and FFs extraction

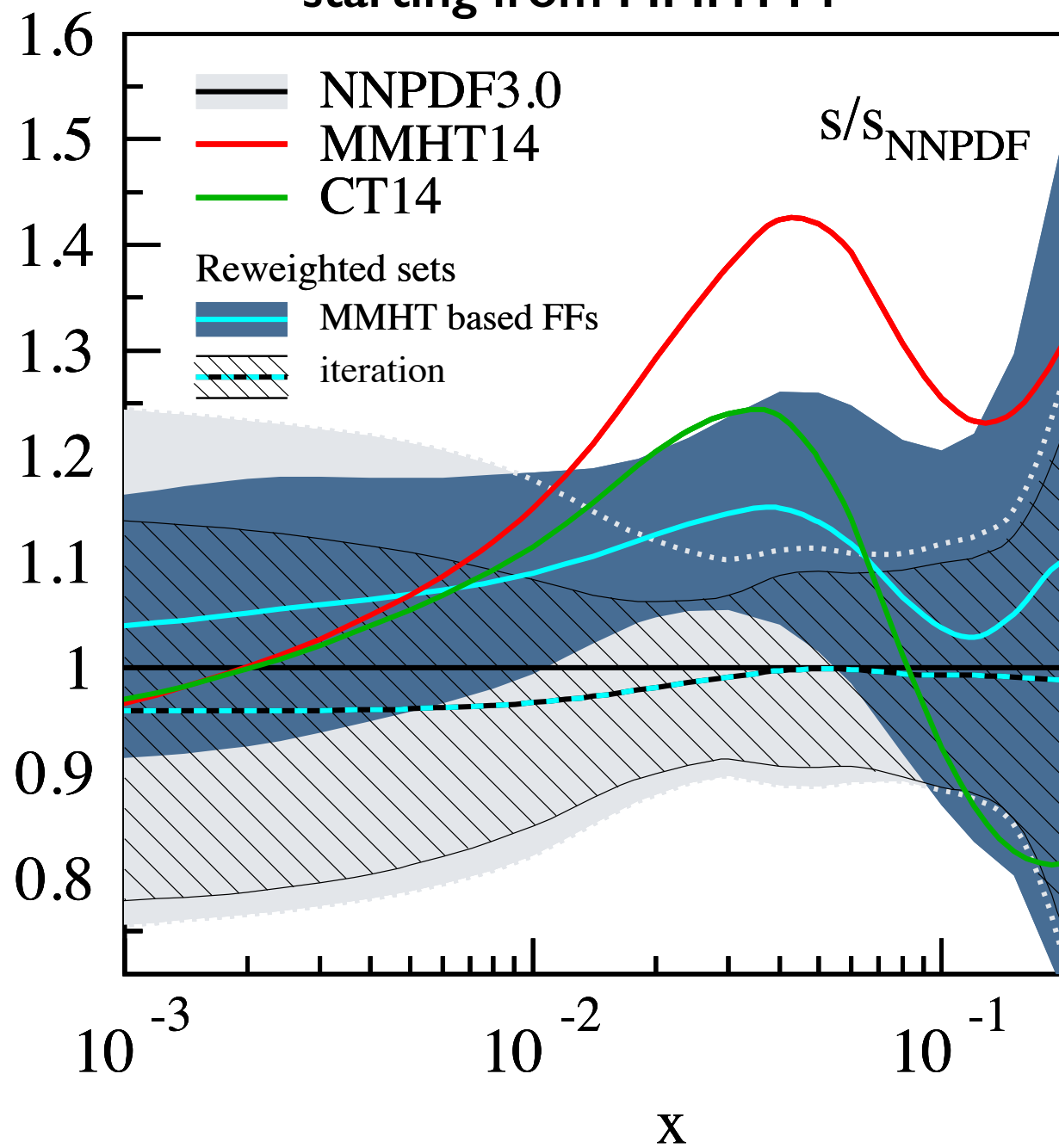
starting from MMHT14



$$\chi^2_{FF} = 1271.7 \quad 1041.3$$

combined PDFs and FFs extraction

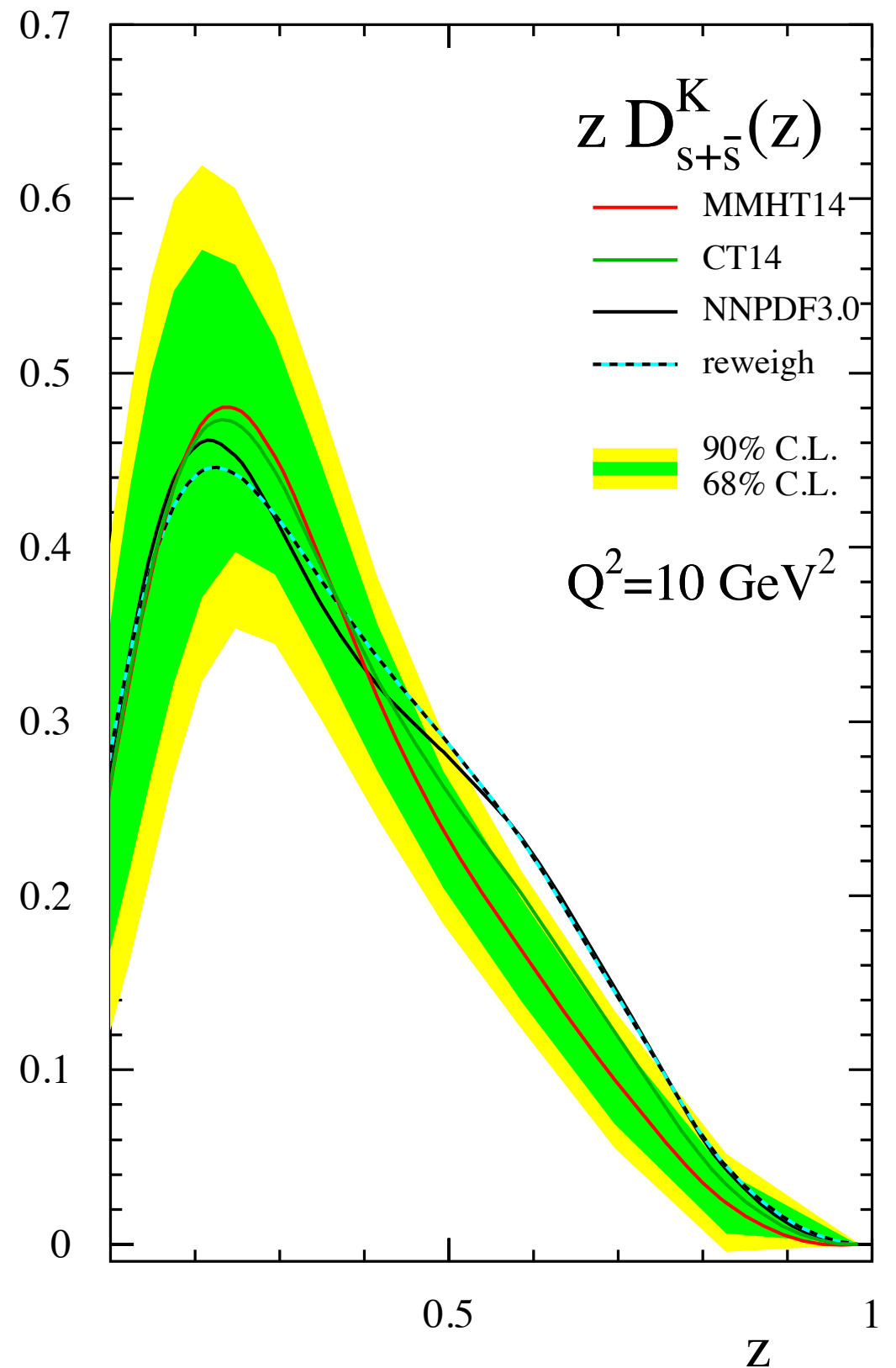
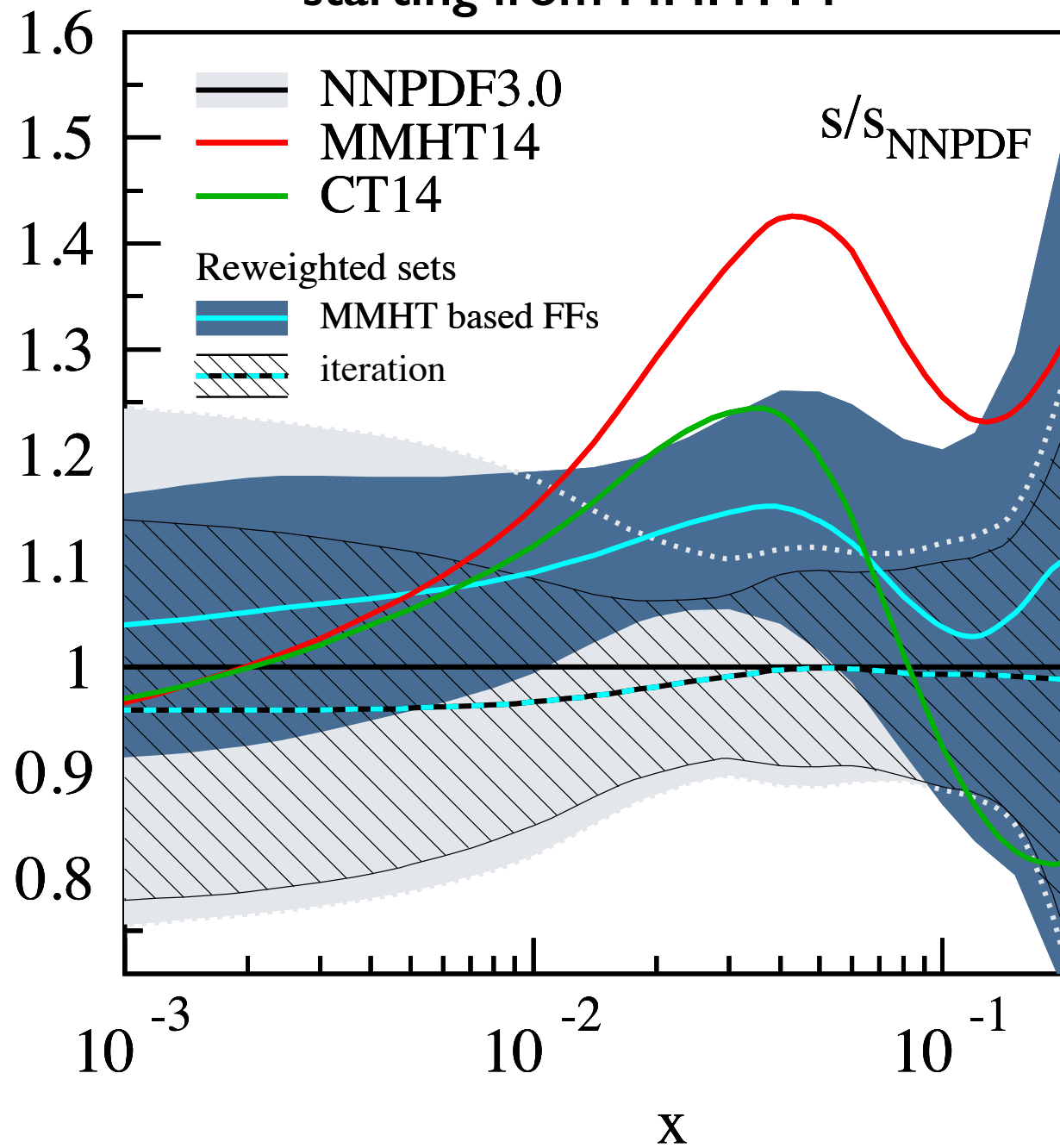
starting from MMHT14



$$\chi^2_{FF} = 1271.7 \quad 1041.3 \quad 1002.3$$

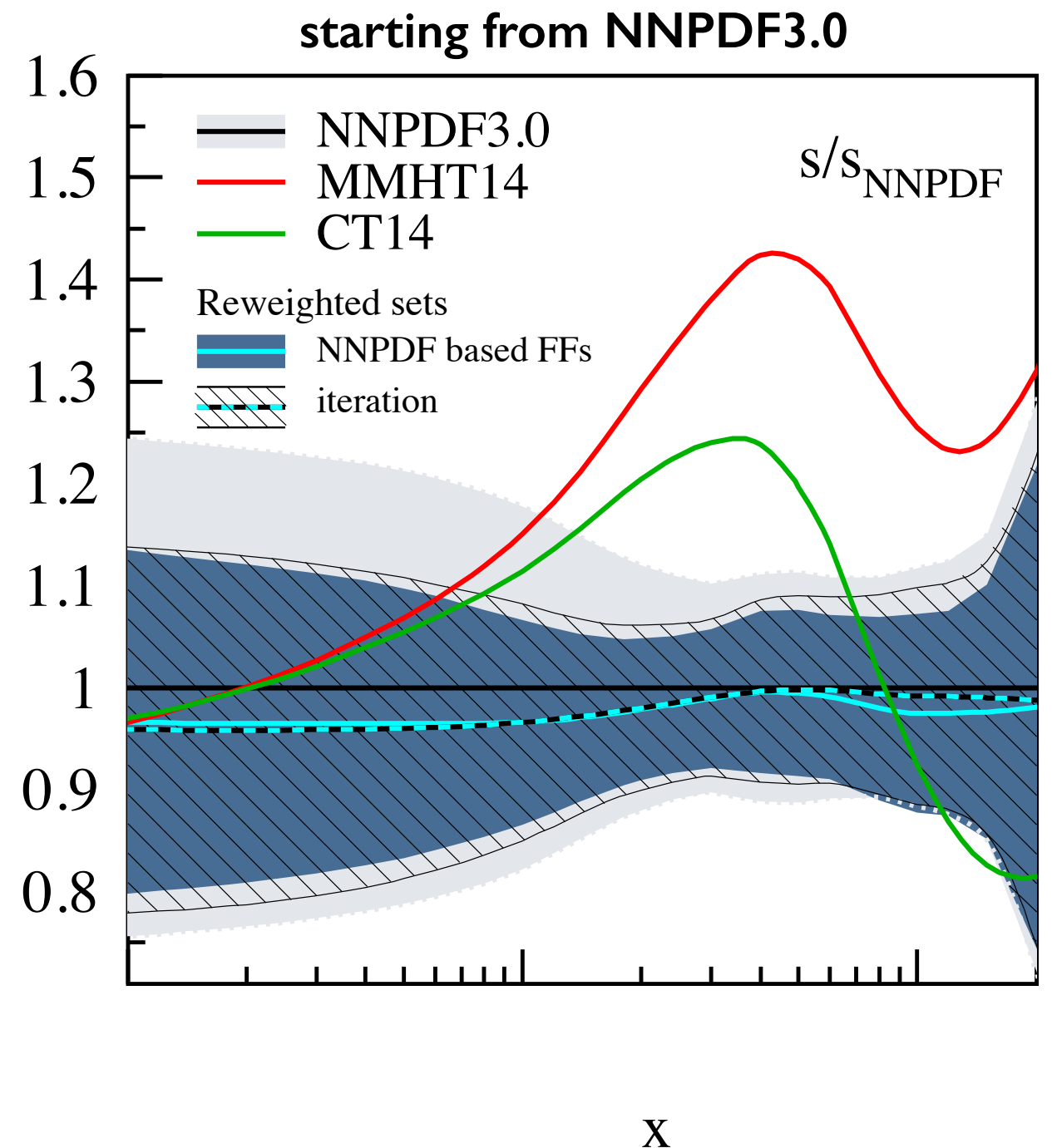
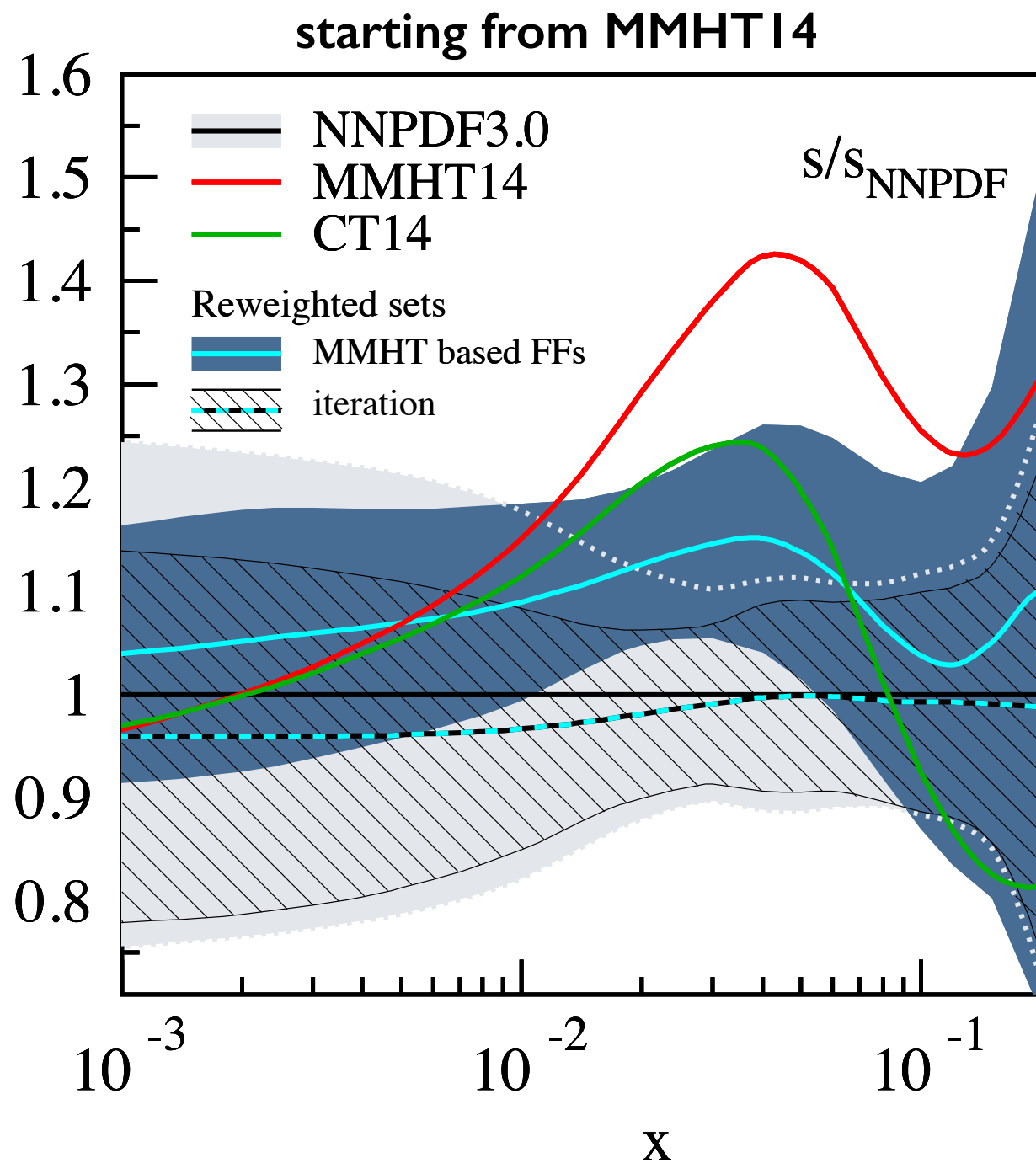
combined PDFs and FFs extraction

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$$\chi_{FF}^2 = 1271.7 \quad 1041.3 \quad 1002.3$$

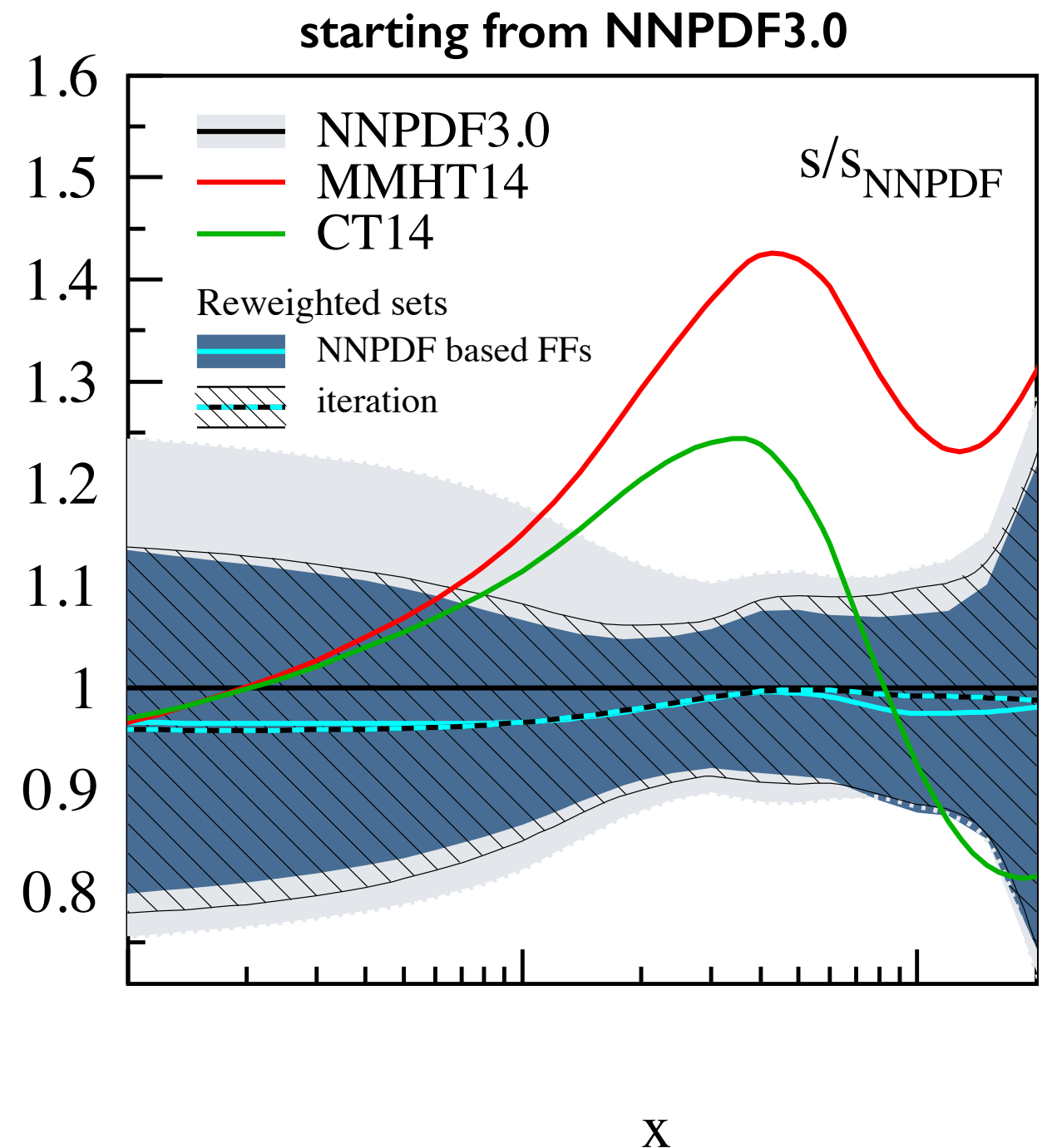
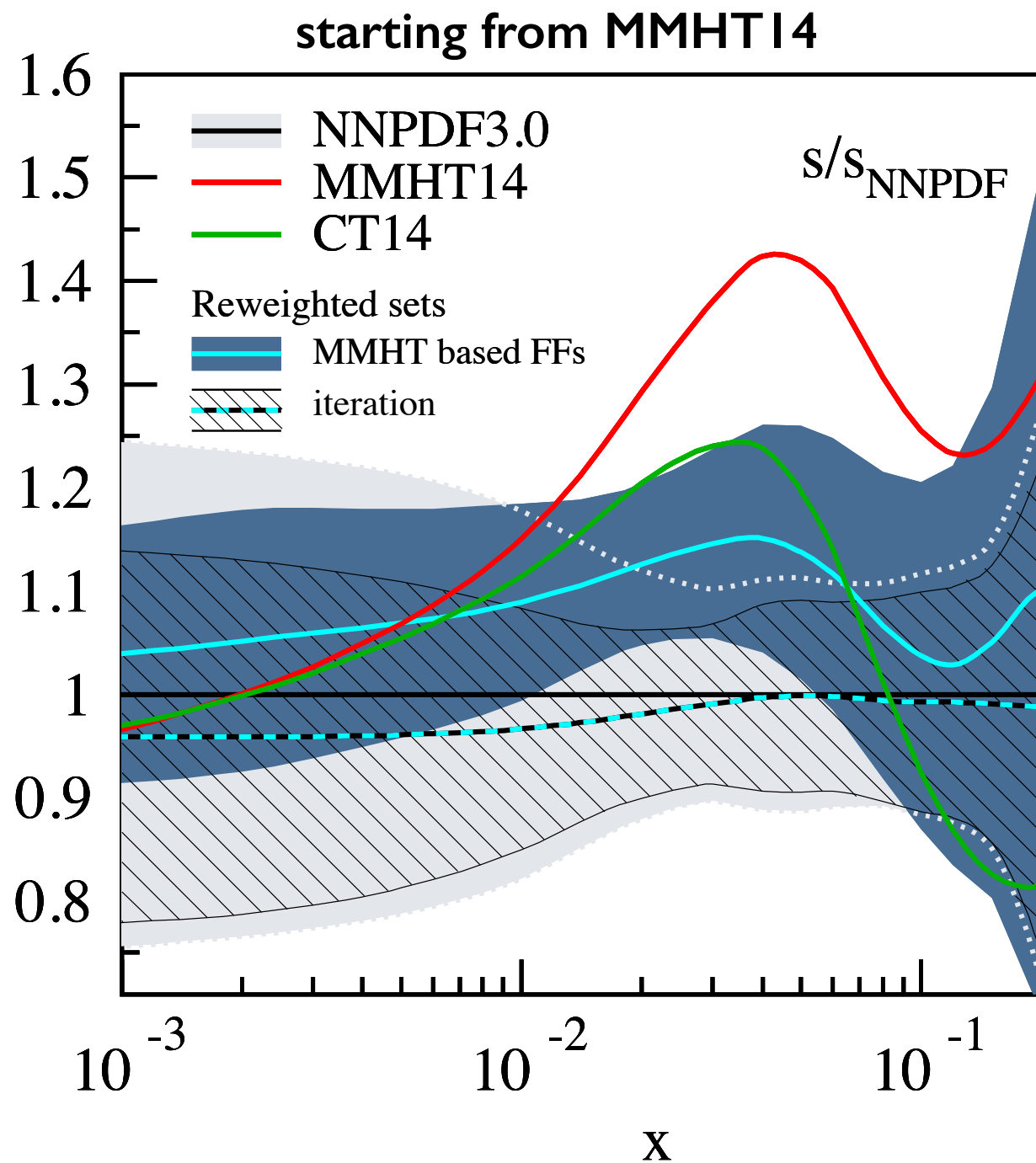
combined PDFs and FFs extraction



$$\chi_{FF}^2 = 1271.7 \quad 1041.3 \quad 1002.3$$

$$1017.2 \quad 1005.3 \quad 1000.6$$

combined PDFs and FFs extraction

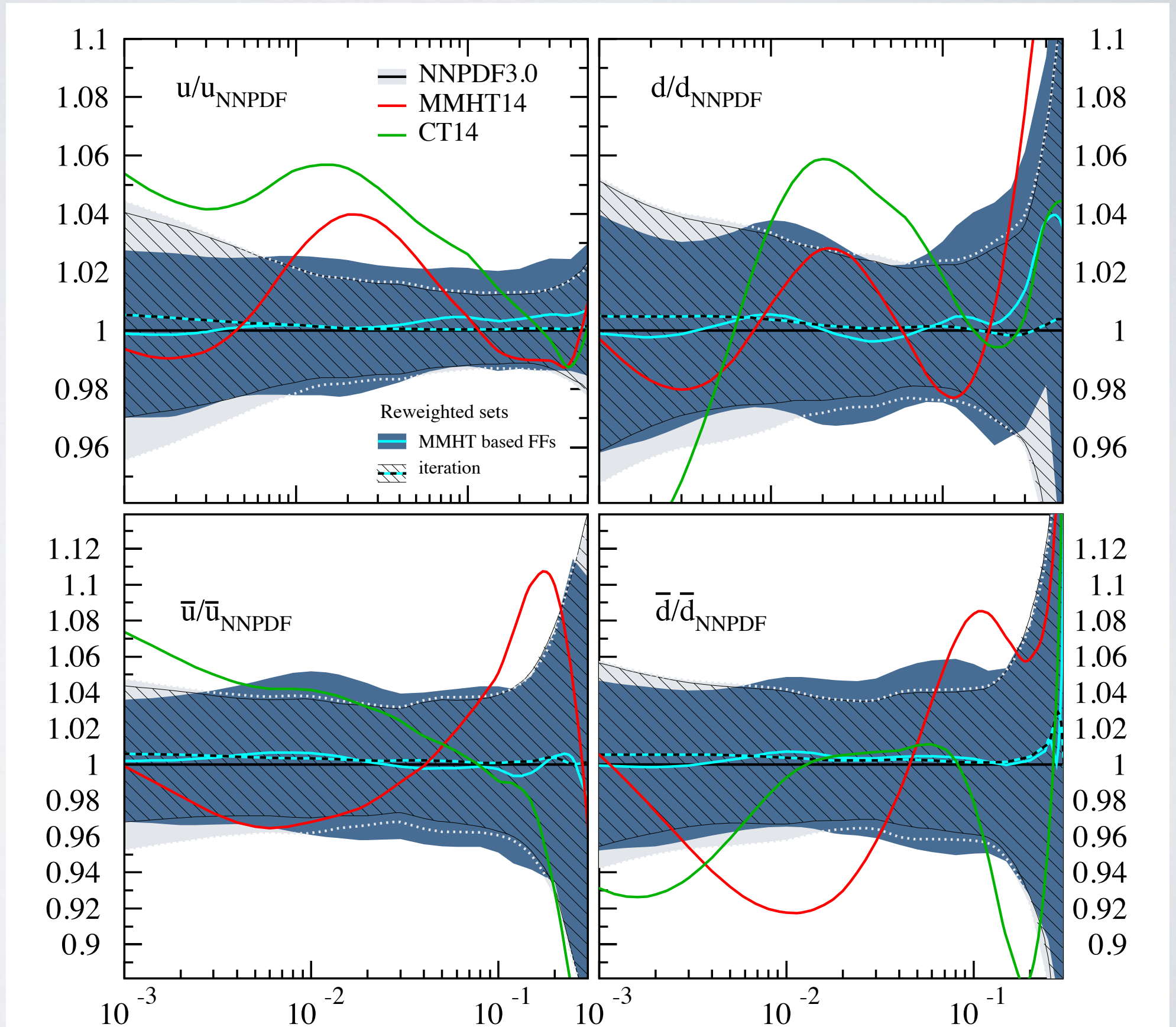


$$\chi_{FF}^2 = 1271.7 \quad 1041.3 \quad 1002.3$$

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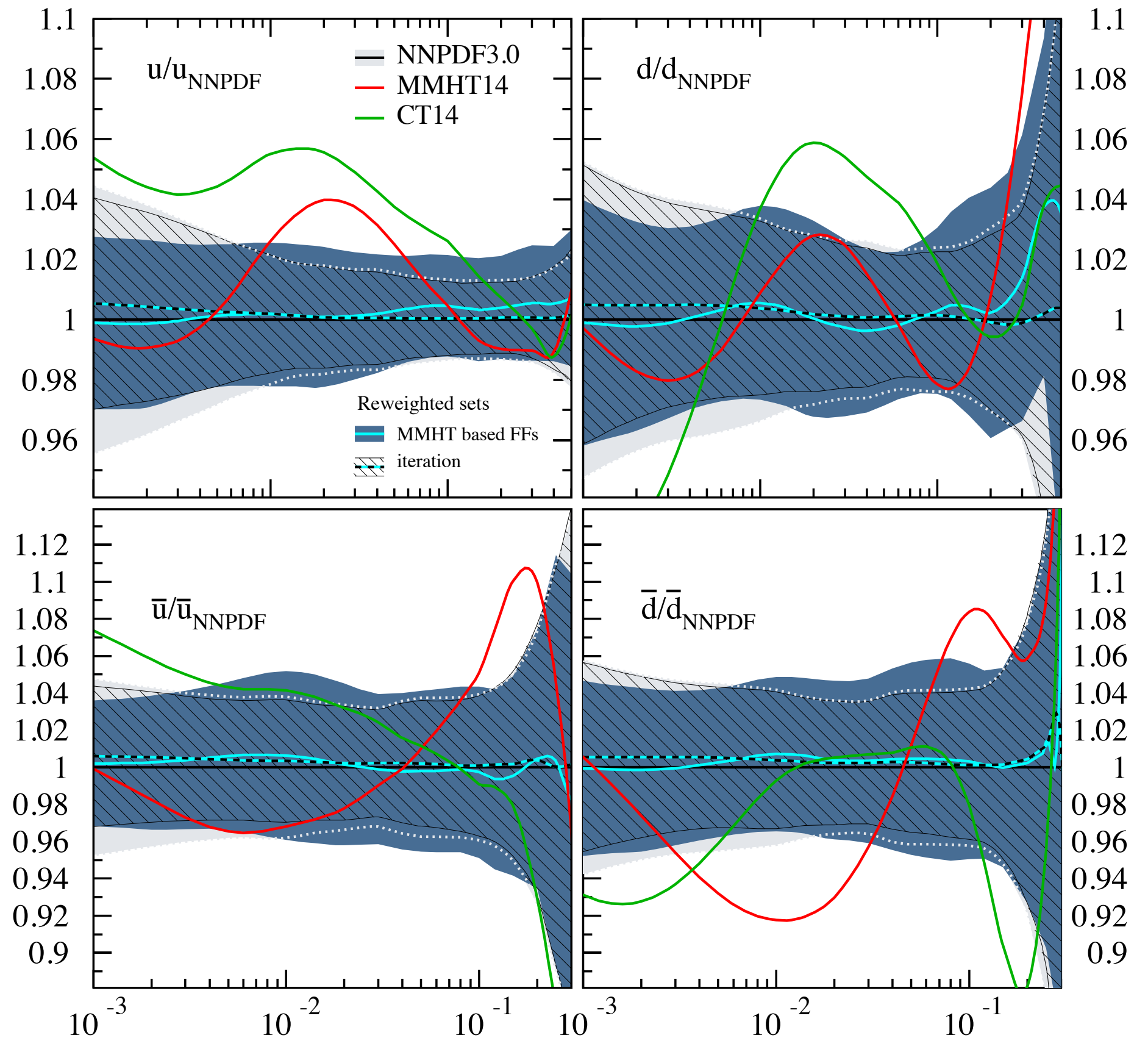
similar results with CT14 replicas

combined PDFs and FFs extraction



combined PDFs and FFs extraction

craving for pions

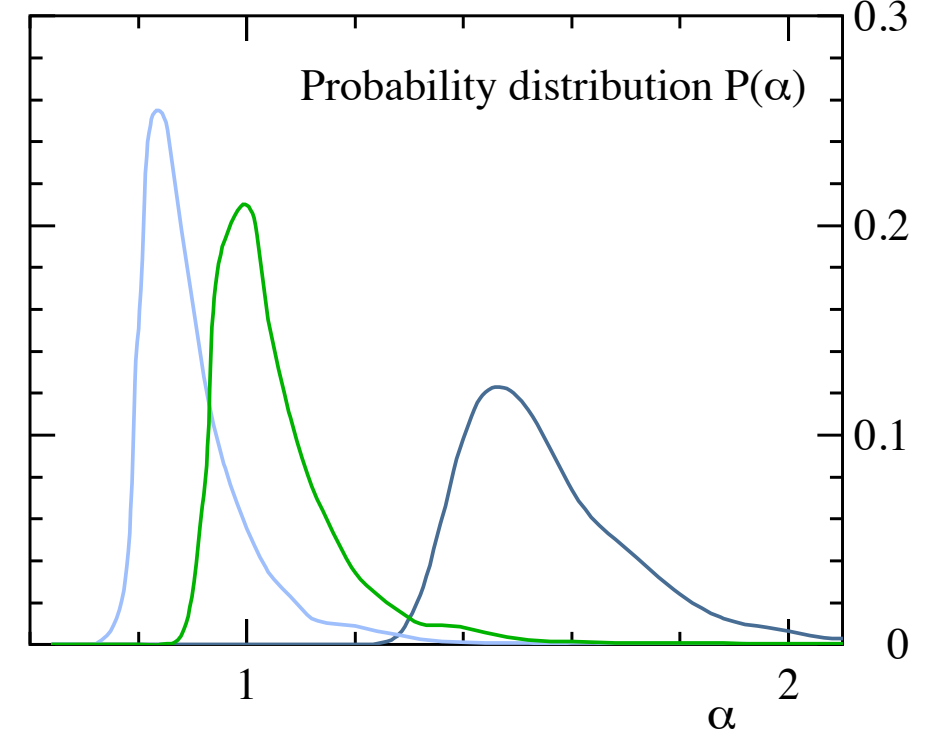
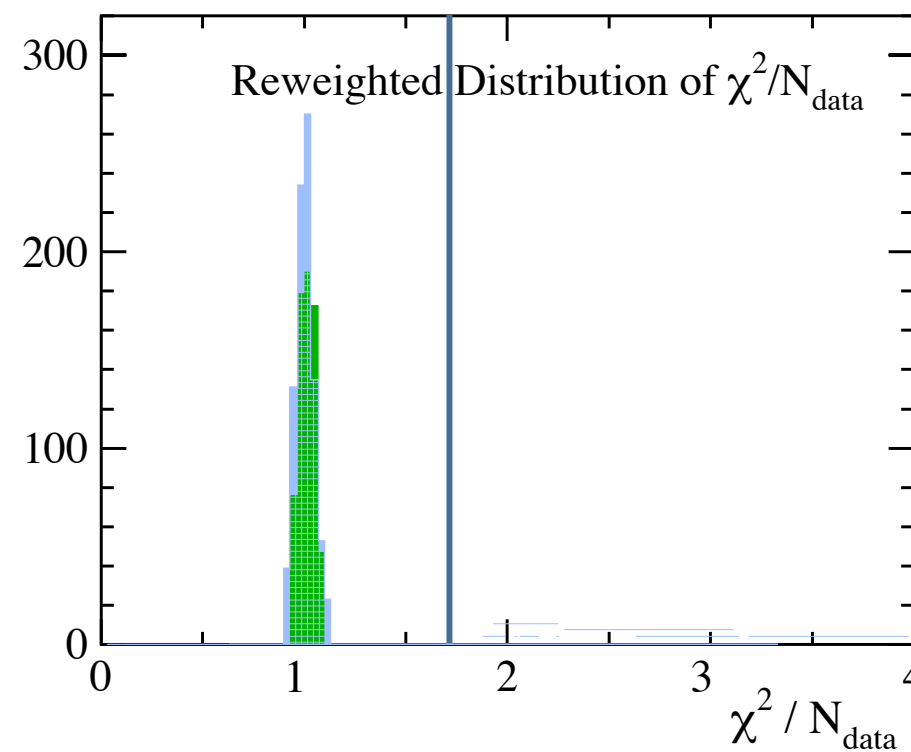
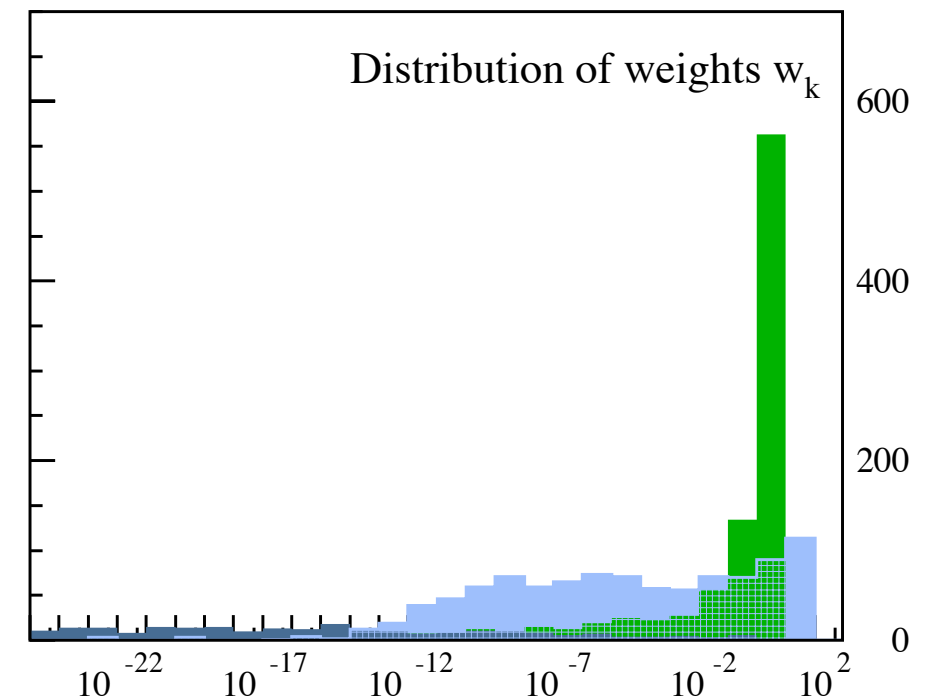
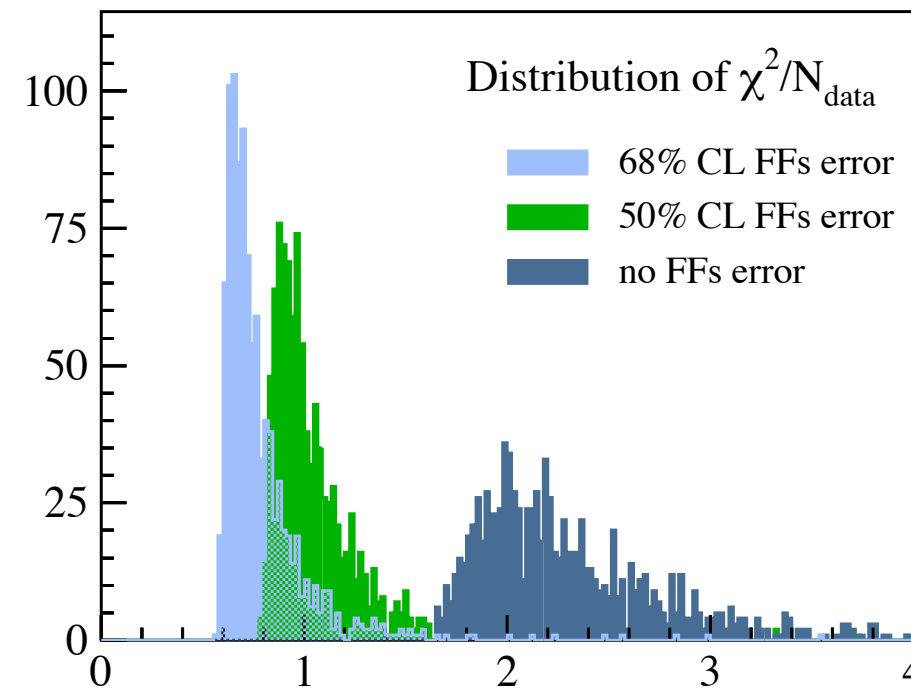


reweighting esoterica:

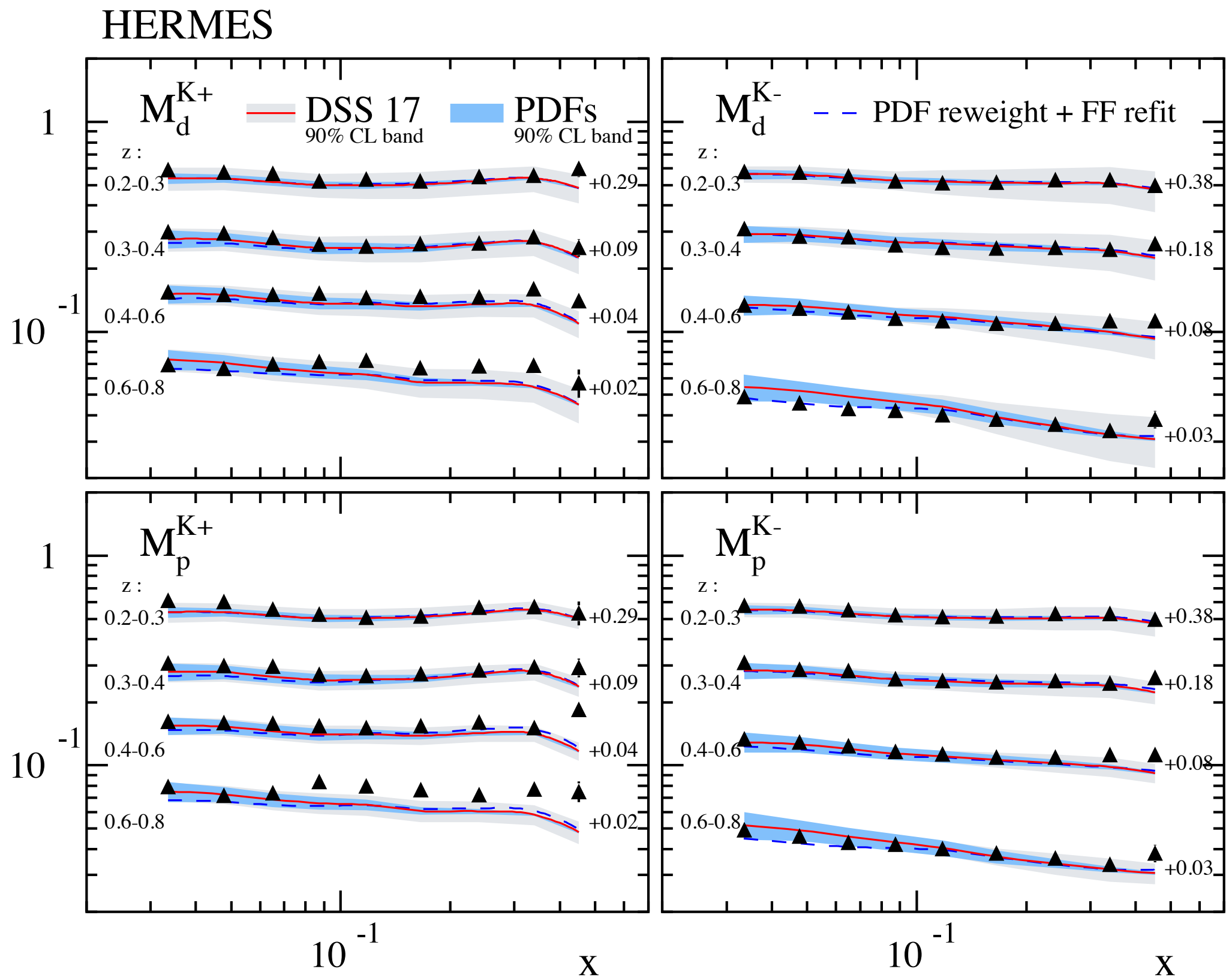
consistency checks:

double counting

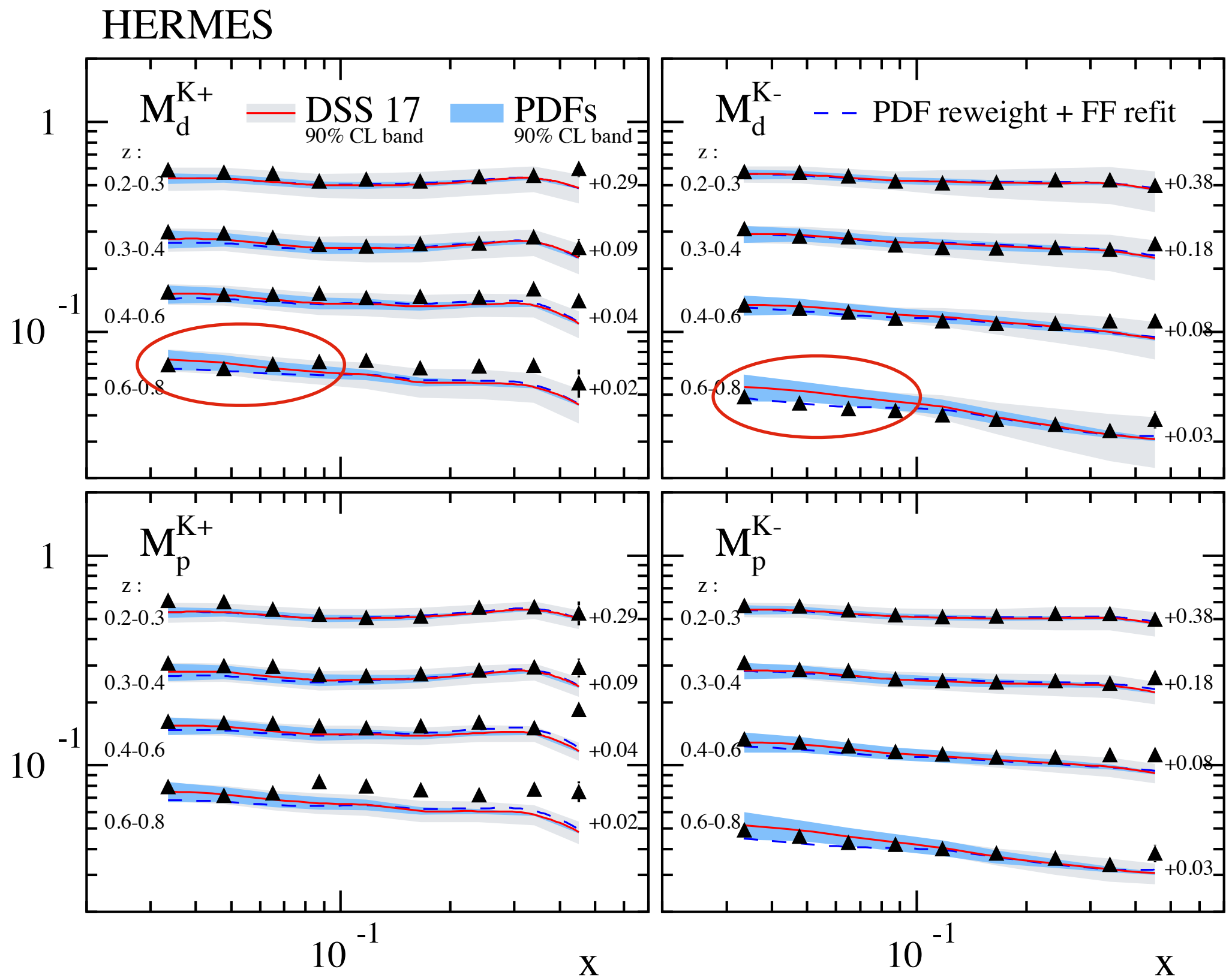
surviving replicas

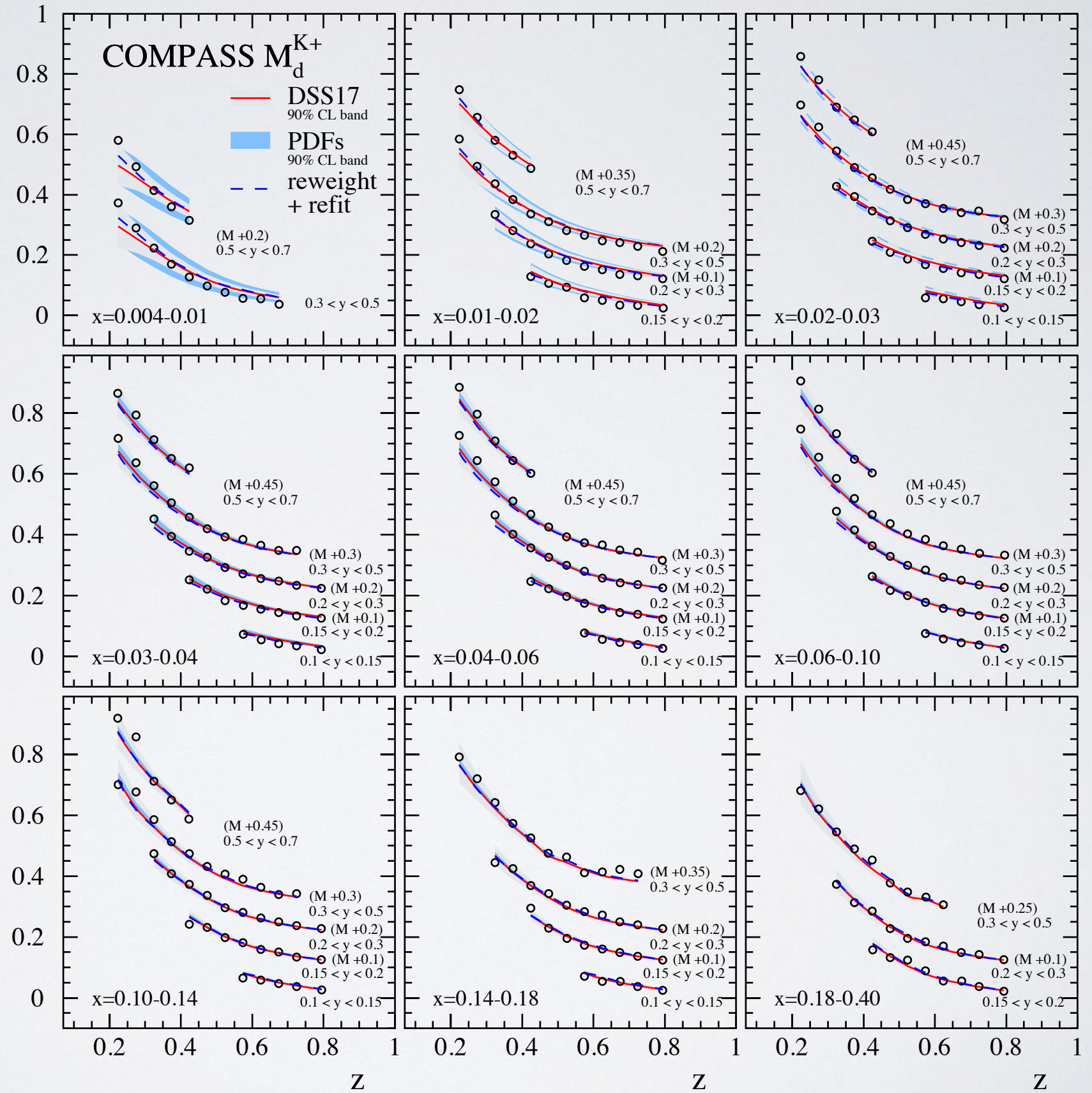


SIDIS revisited:

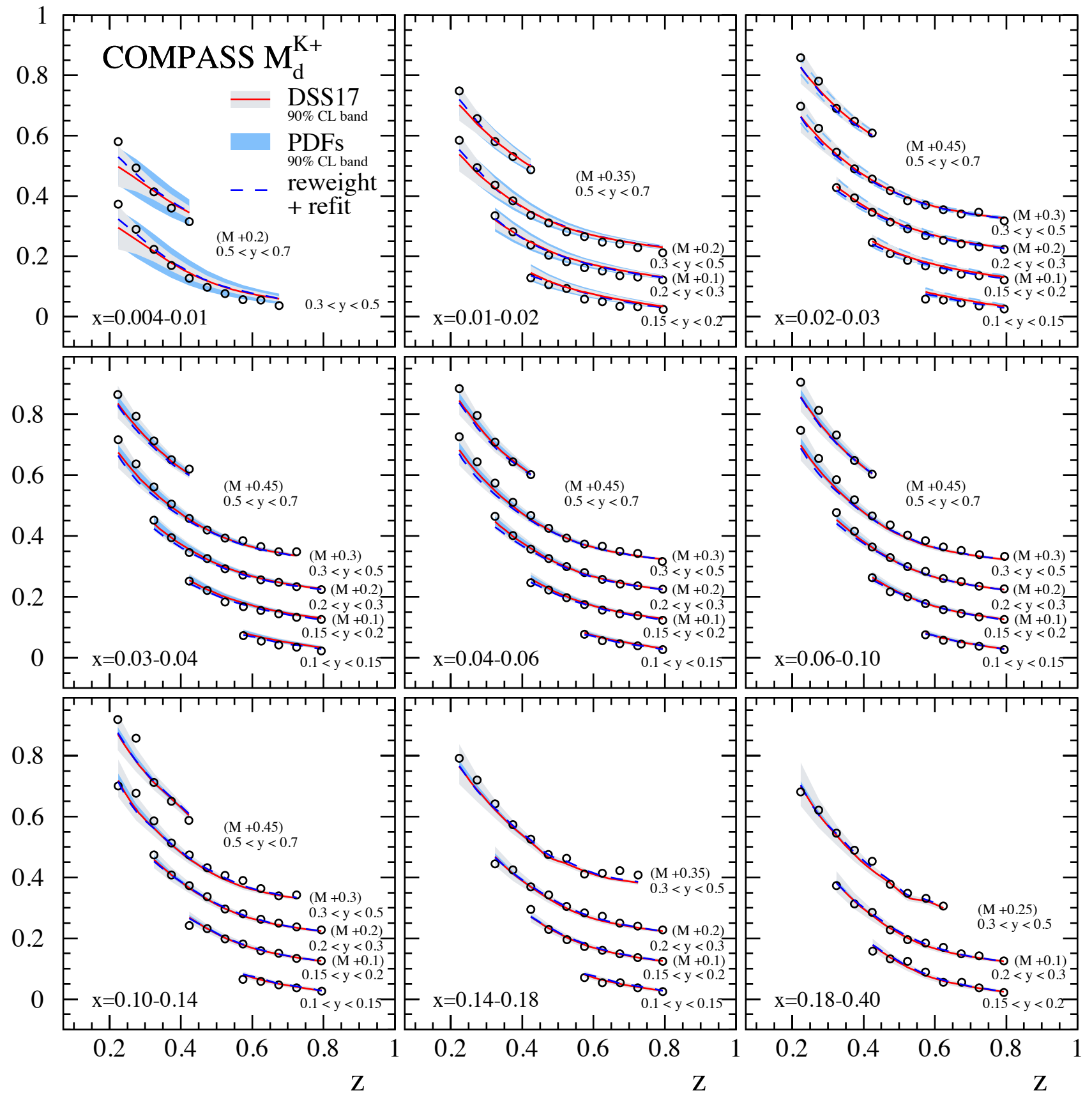


SIDIS revisited:

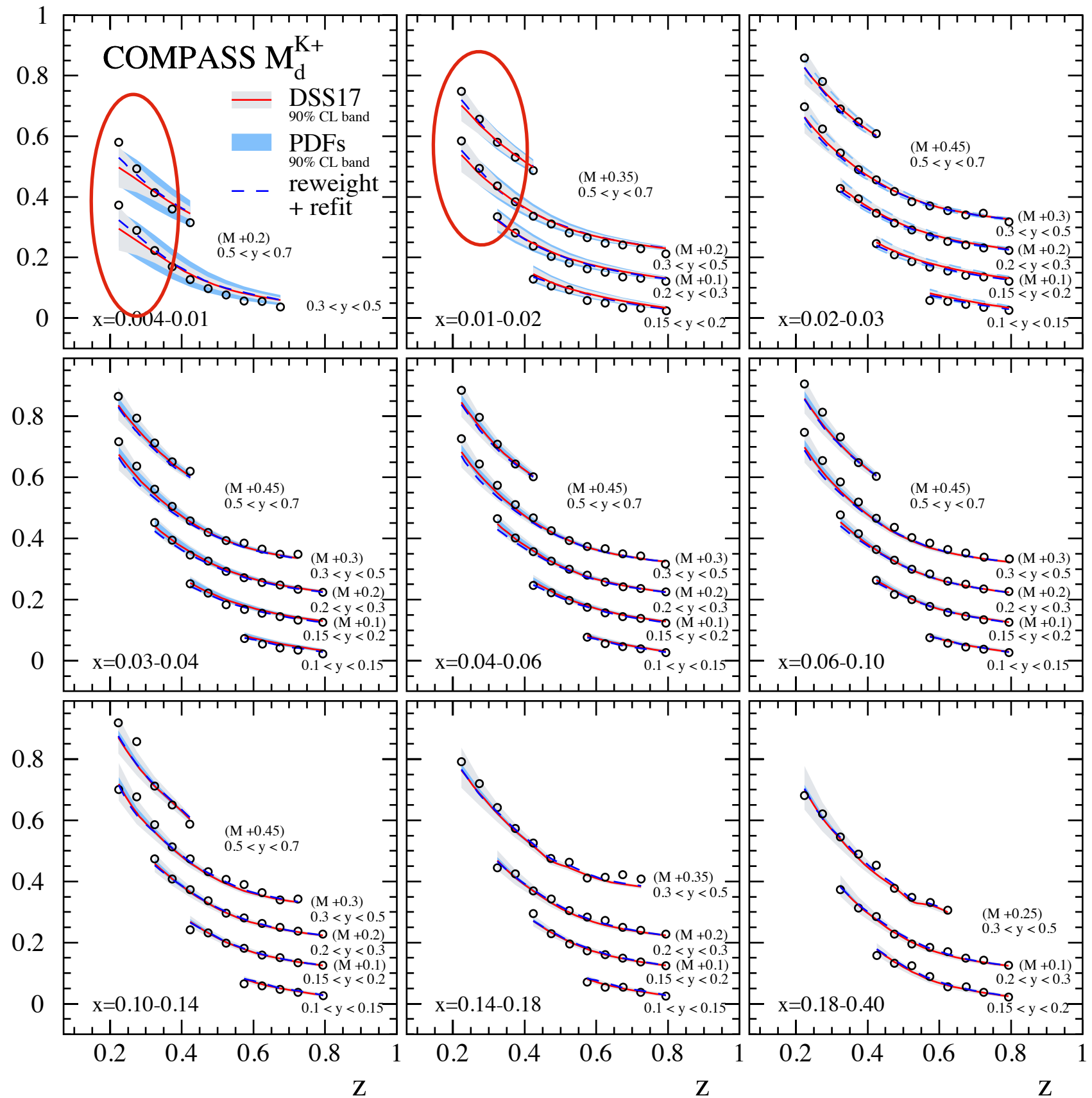




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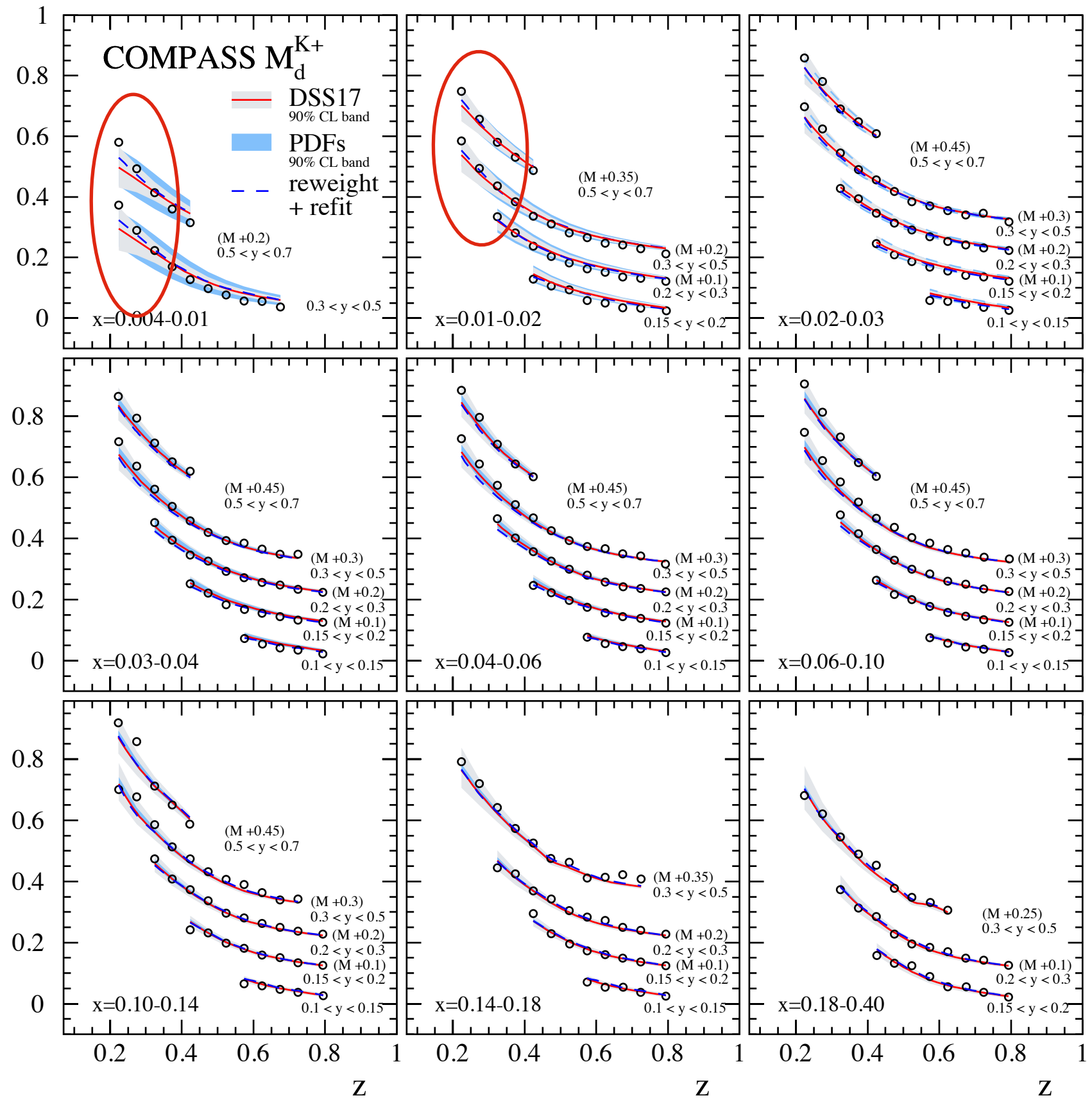


SIDIS revisited:

555.9

467.6

434.5



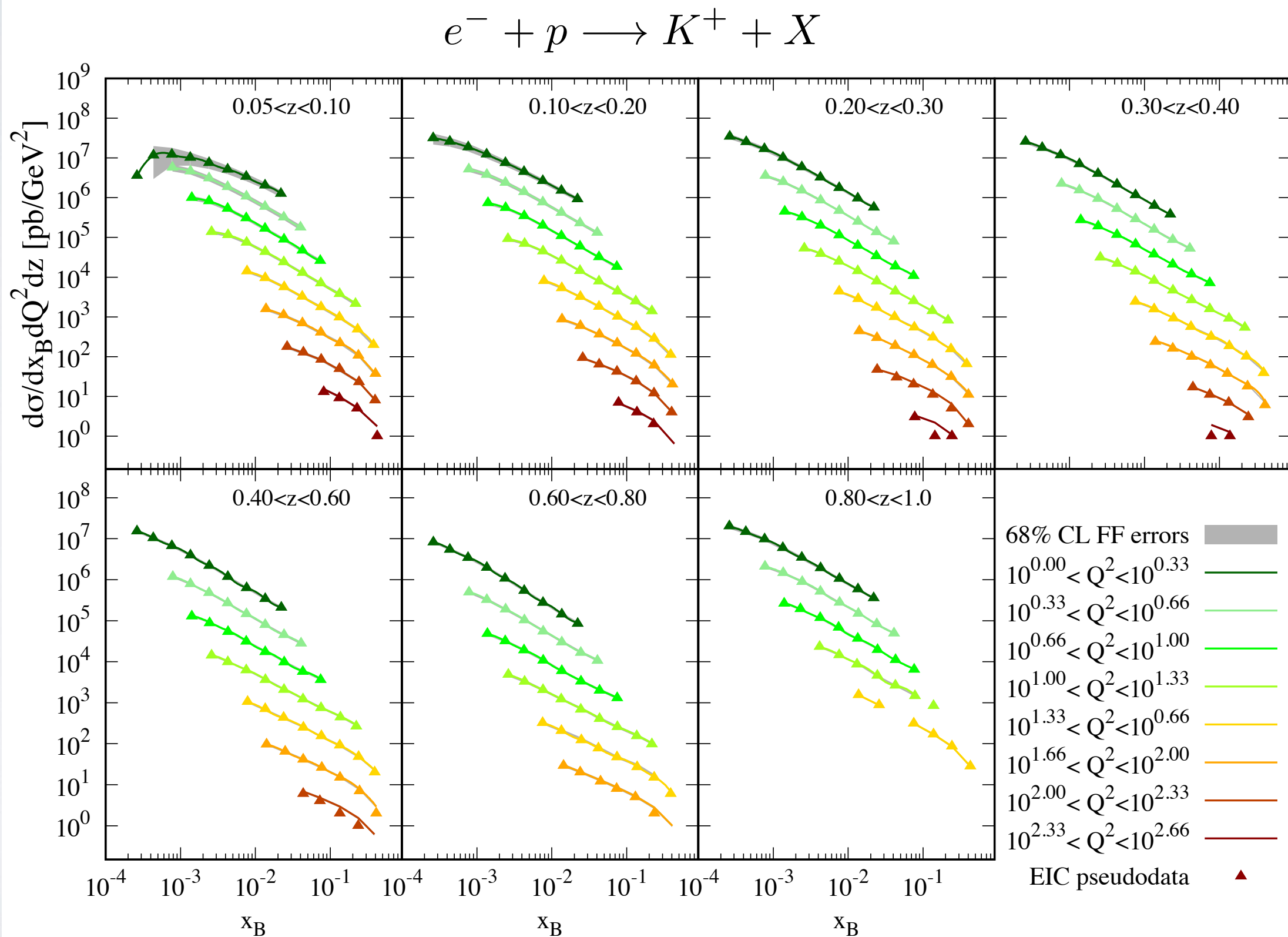
SIDIS at EIC:

in collaboration with E.Aschenauer, I. Borsa, M. Stratmann, C.Van Hulse

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$E_e = 15 \text{ GeV}$
 $E_p = 100 \text{ GeV}$
 10 fb^{-1}



SIDIS at EIC:

$E_e = 15 \text{ GeV}$

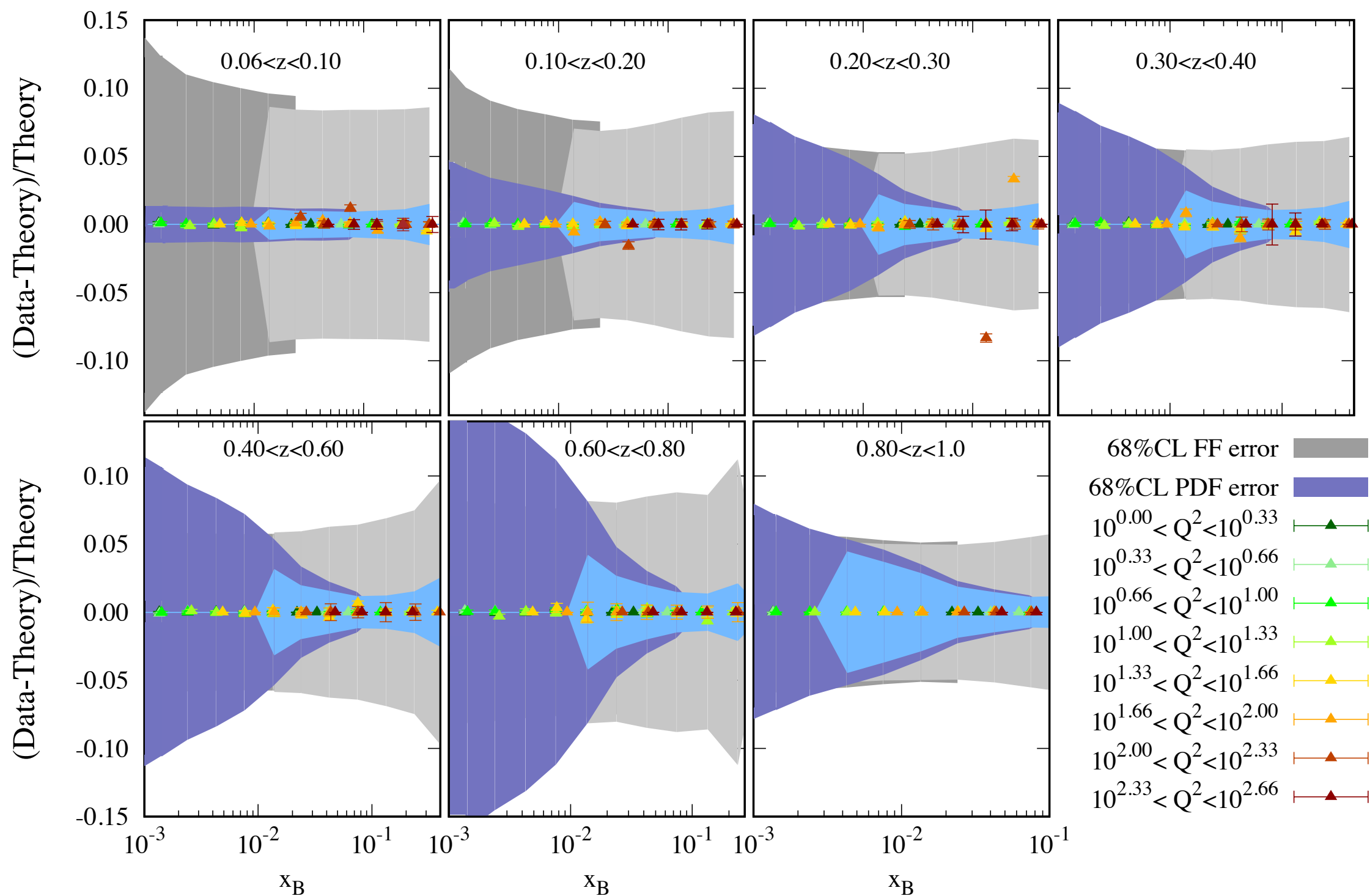
$E_p = 100 \text{ GeV}$

10 fb^{-1}

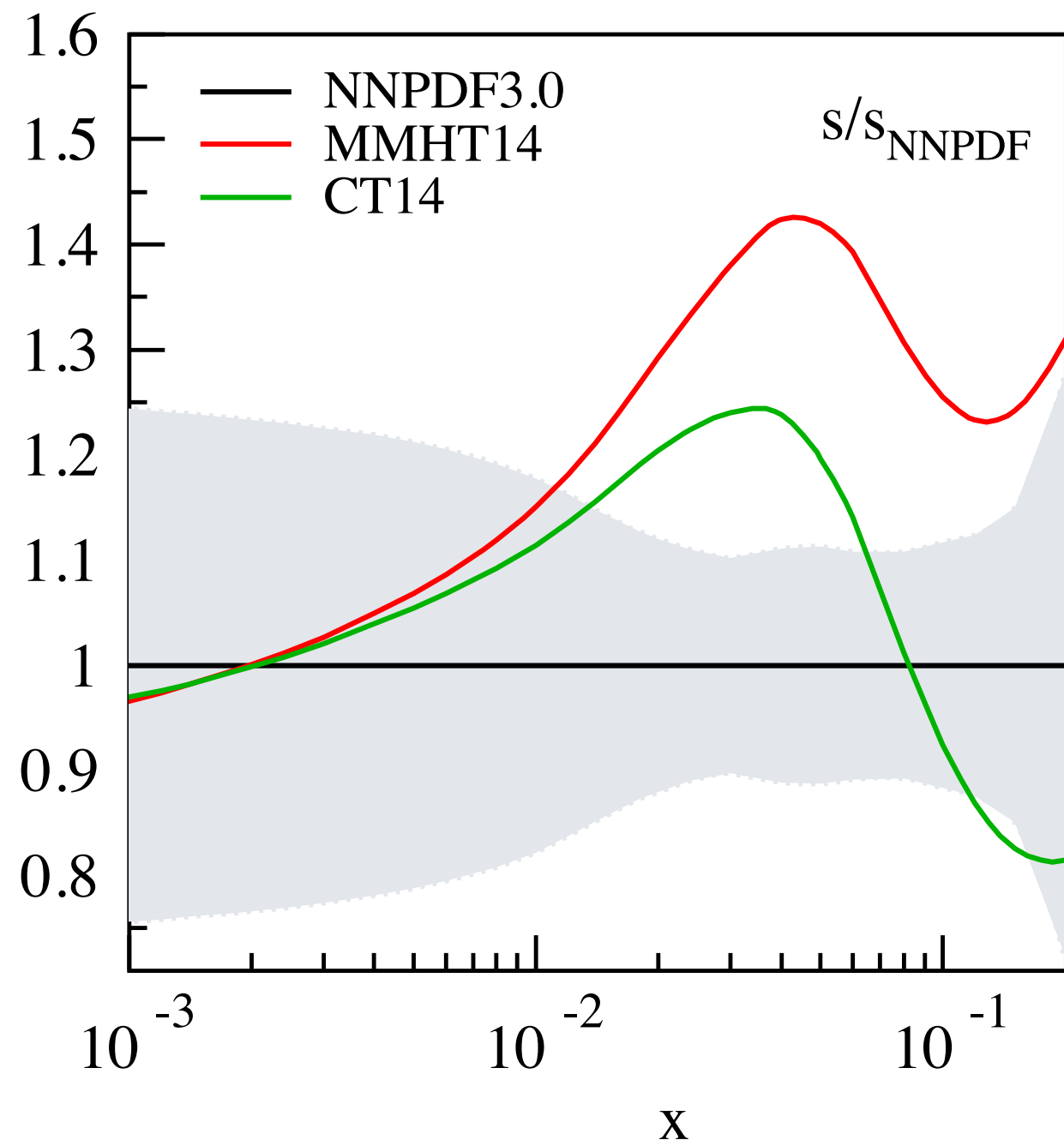
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 10 fb^{-1}

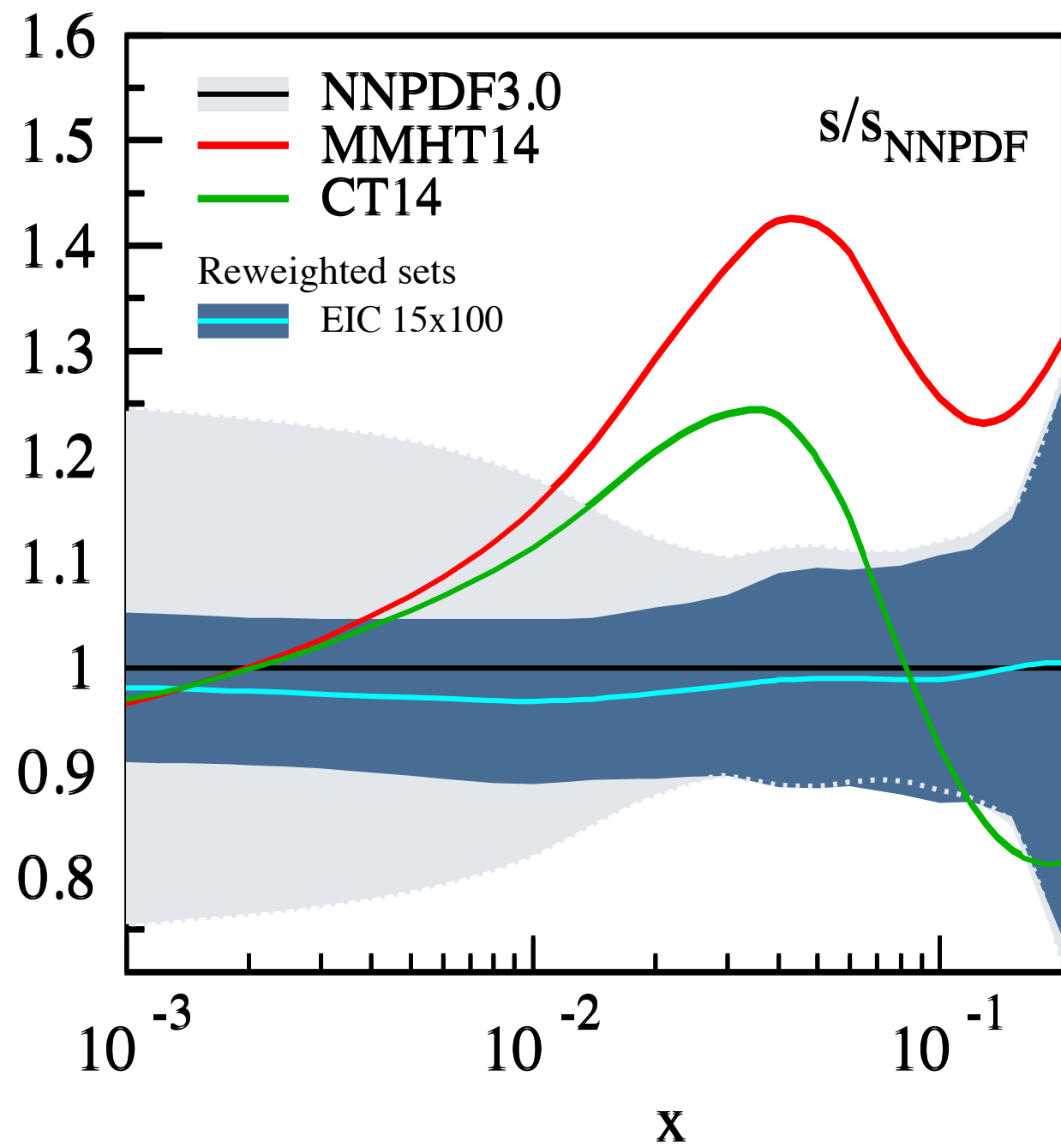
$$e^- + p \longrightarrow K^+ + X$$



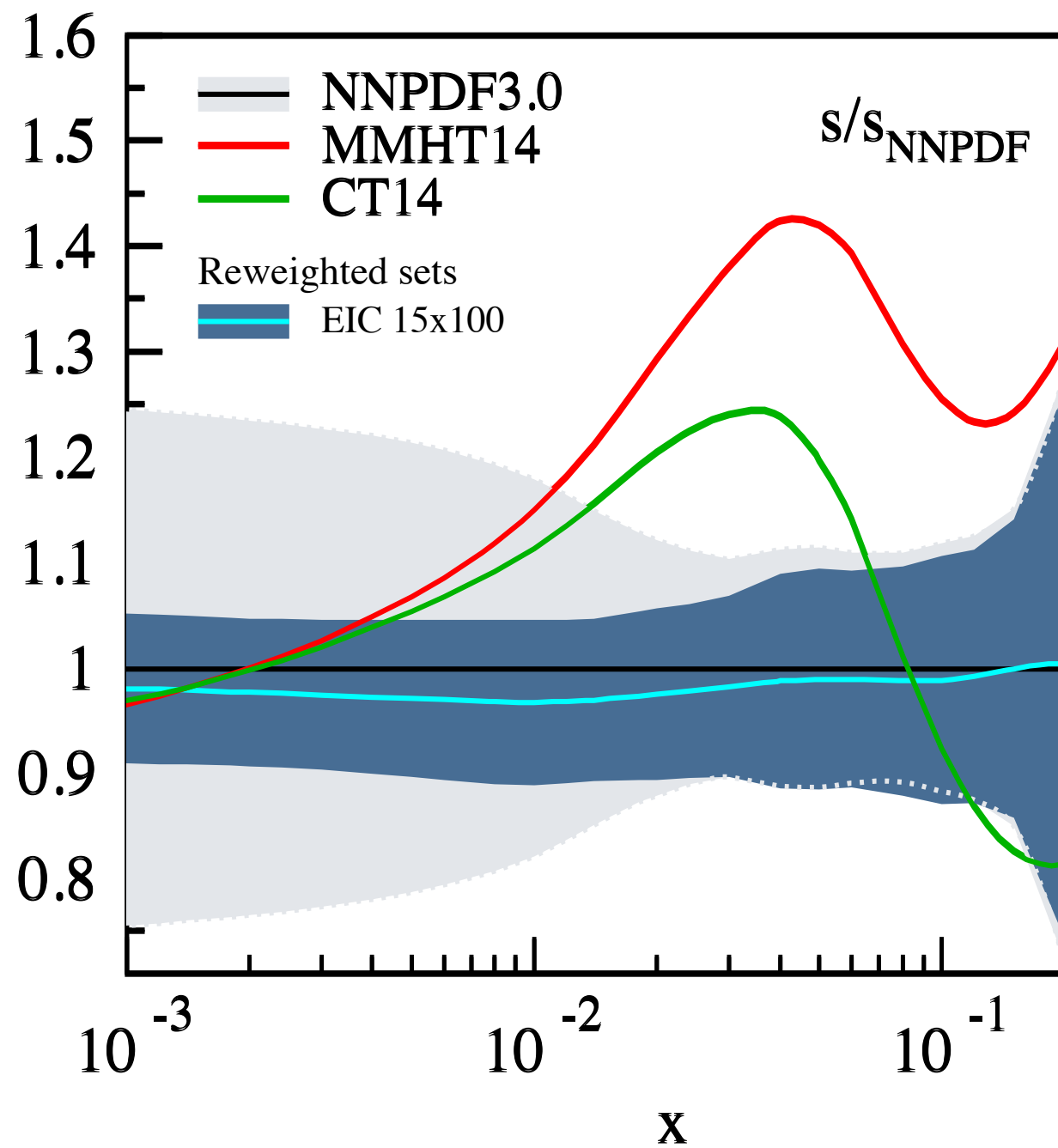
SIDIS at EIC:



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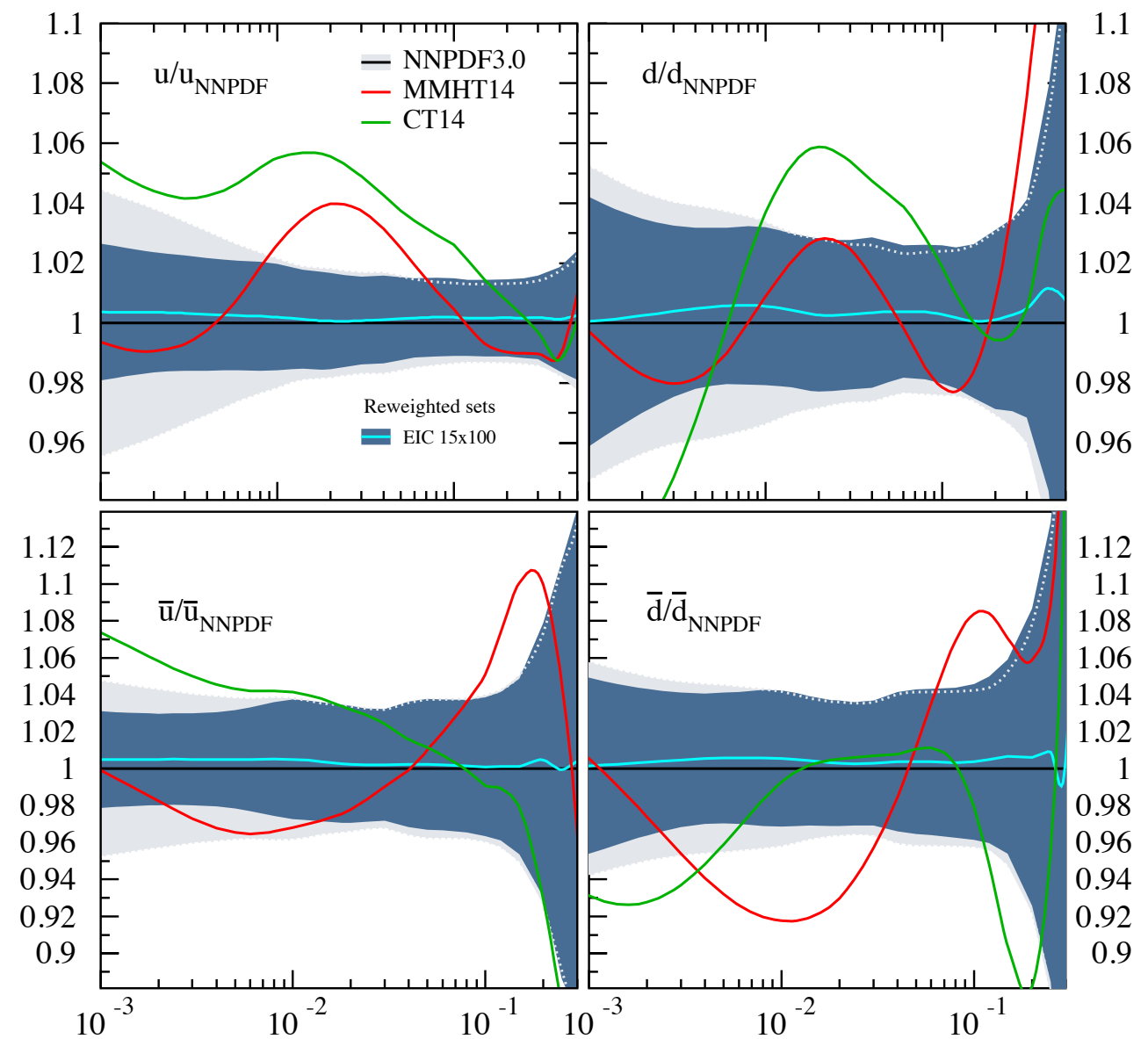
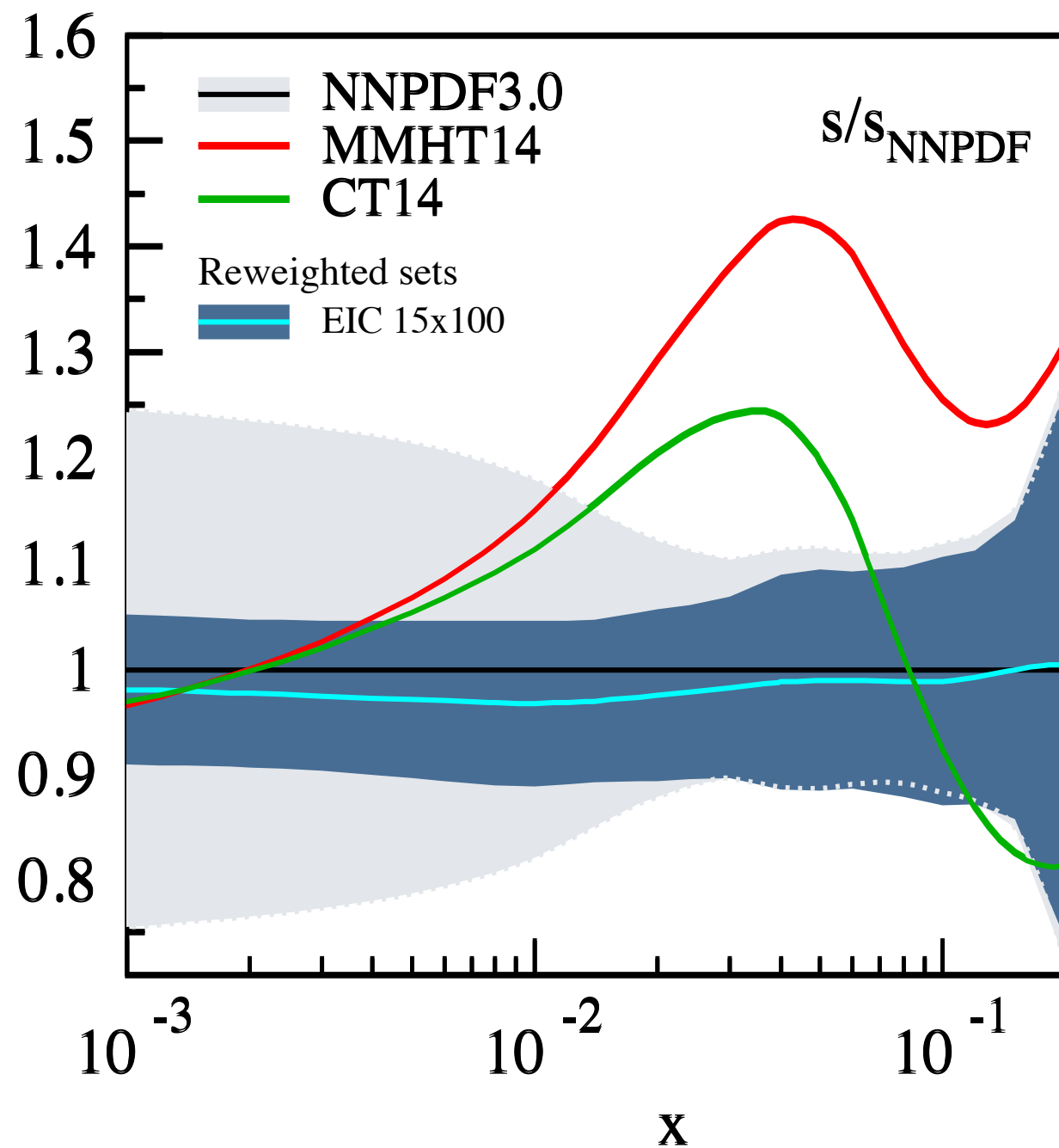


SIDIS at EIC:



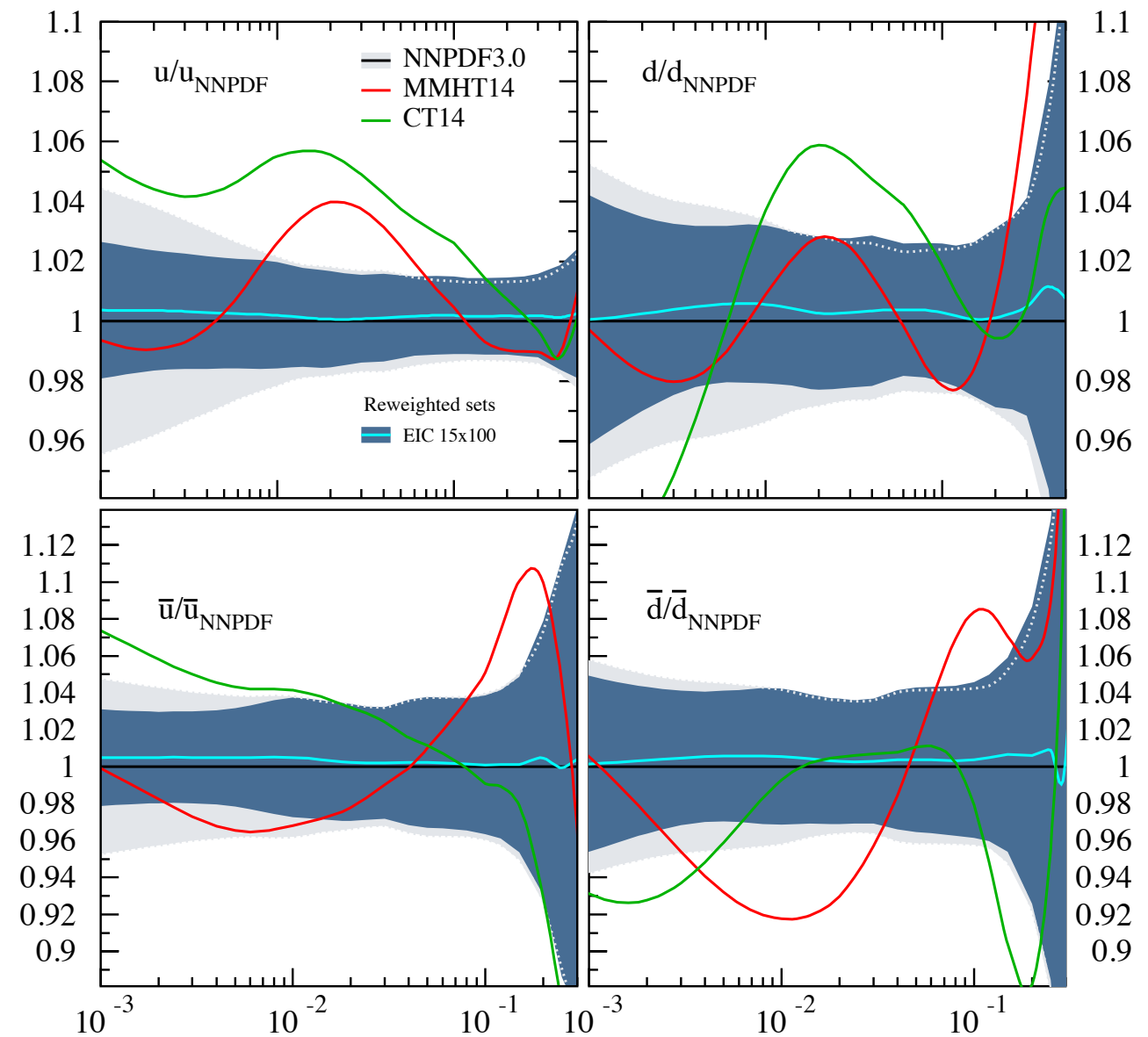
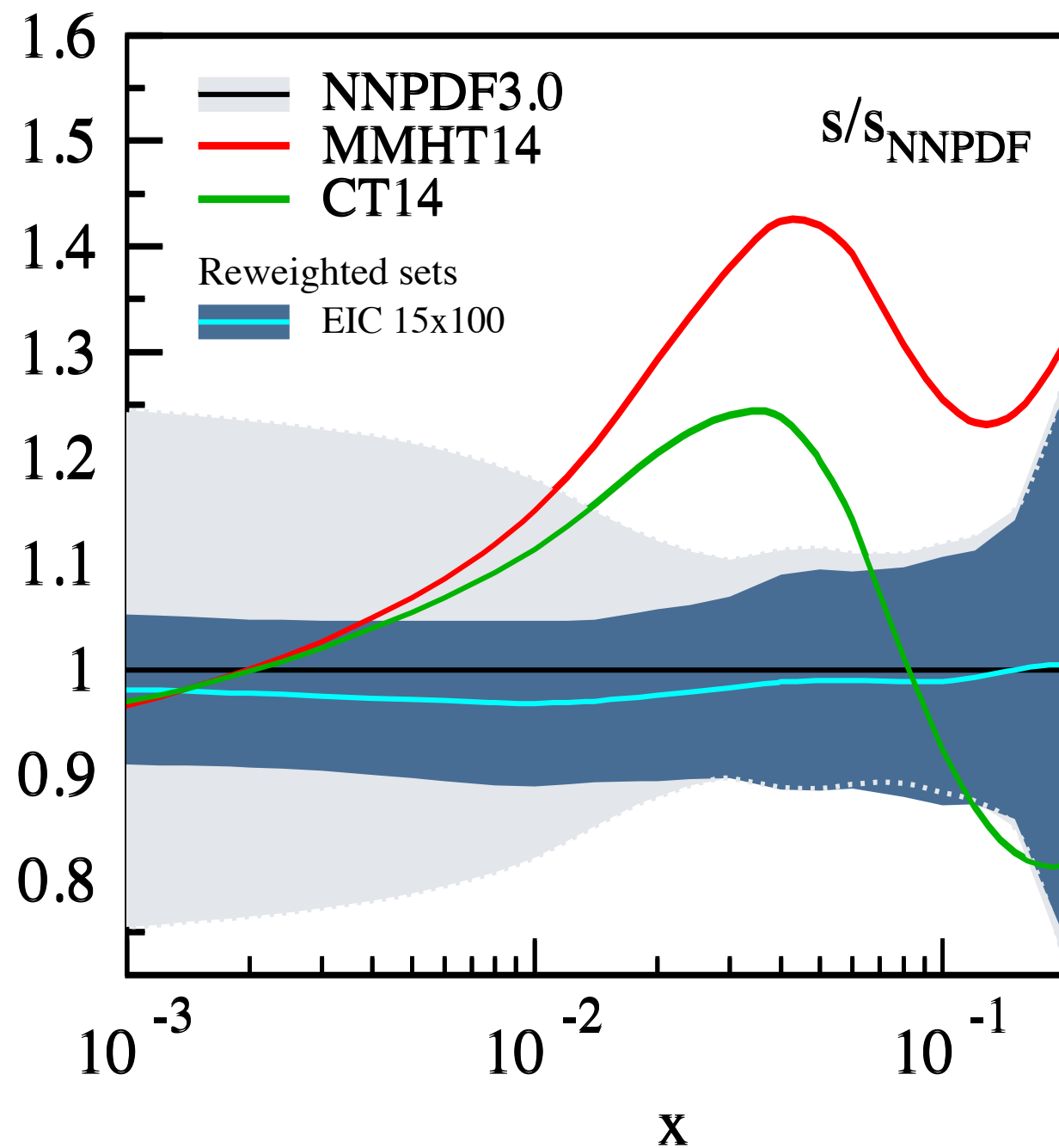
precision tool for:
strangeness in the proton

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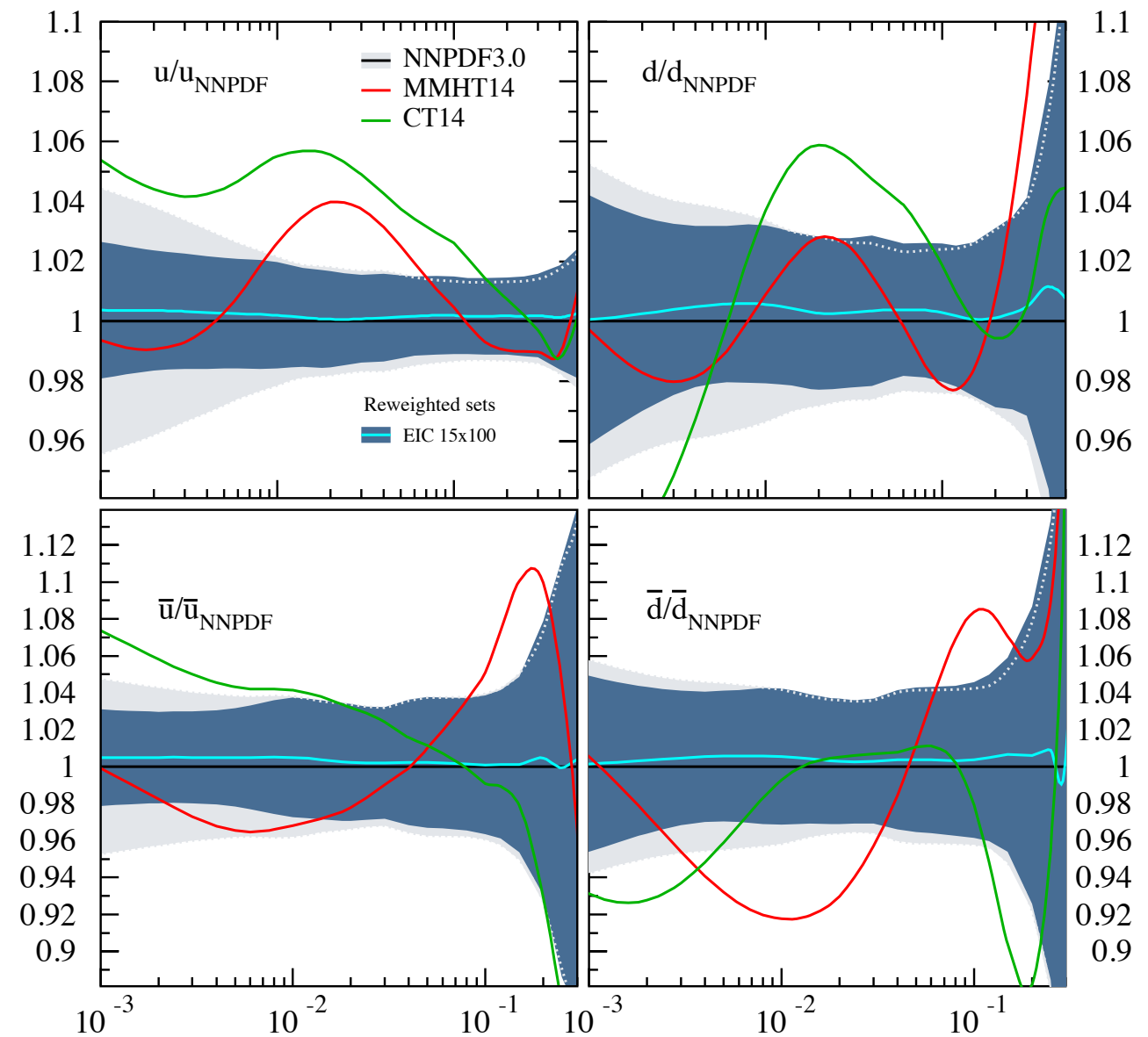
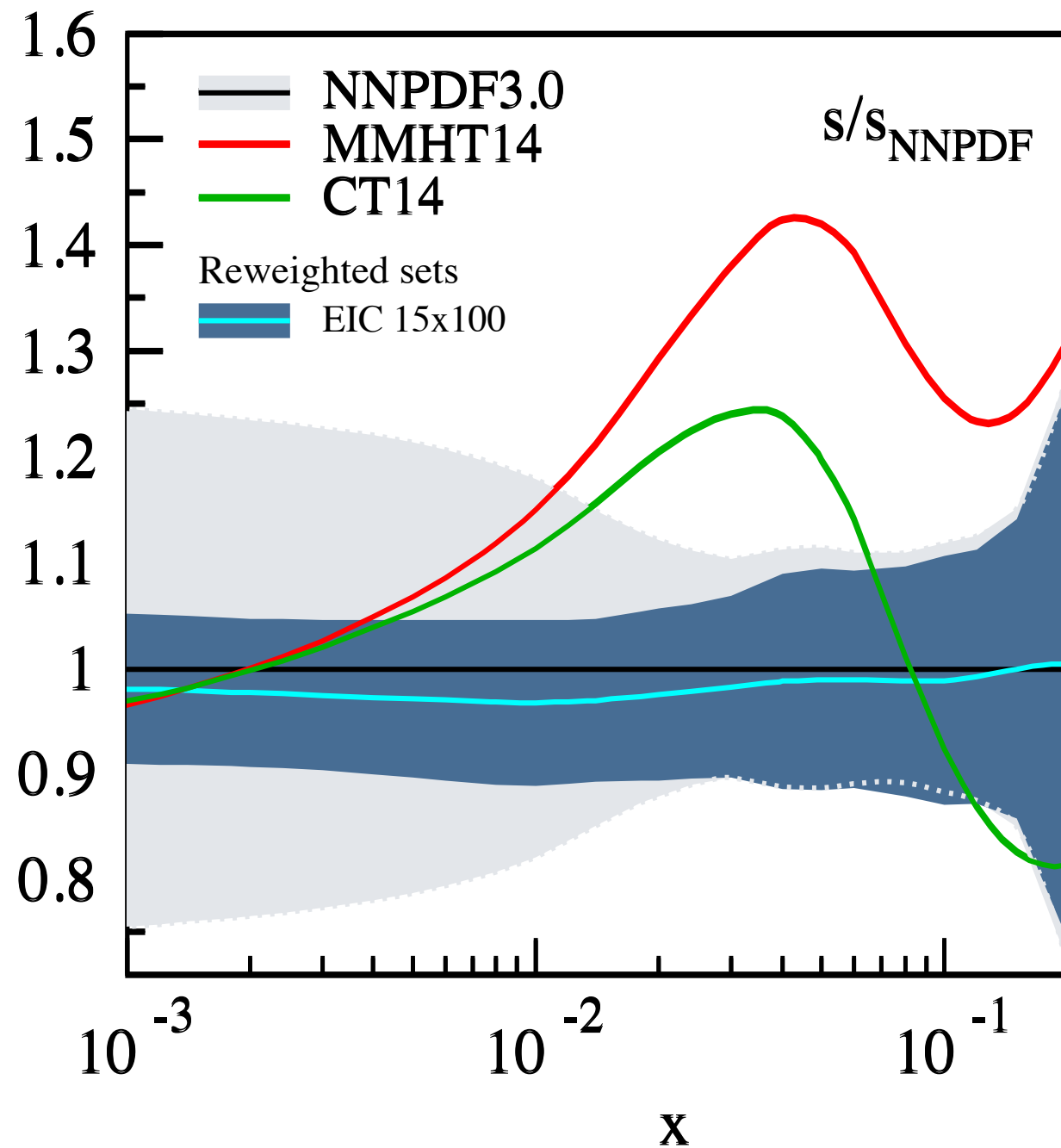
SIDIS at EIC:



precision tool for:

strangeness in the proton
isospin breaking
charge symmetry breaking

SIDIS at EIC:

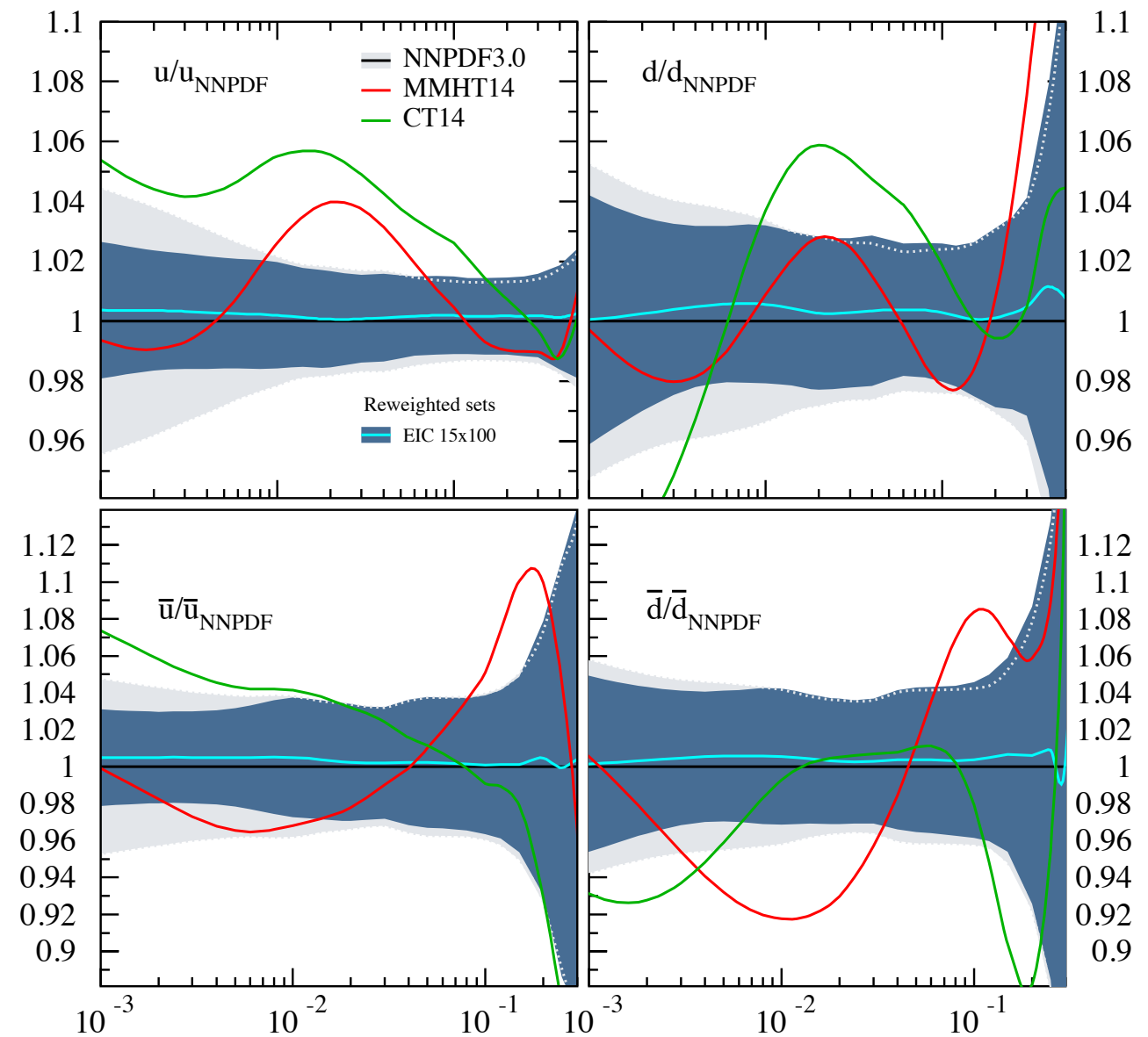
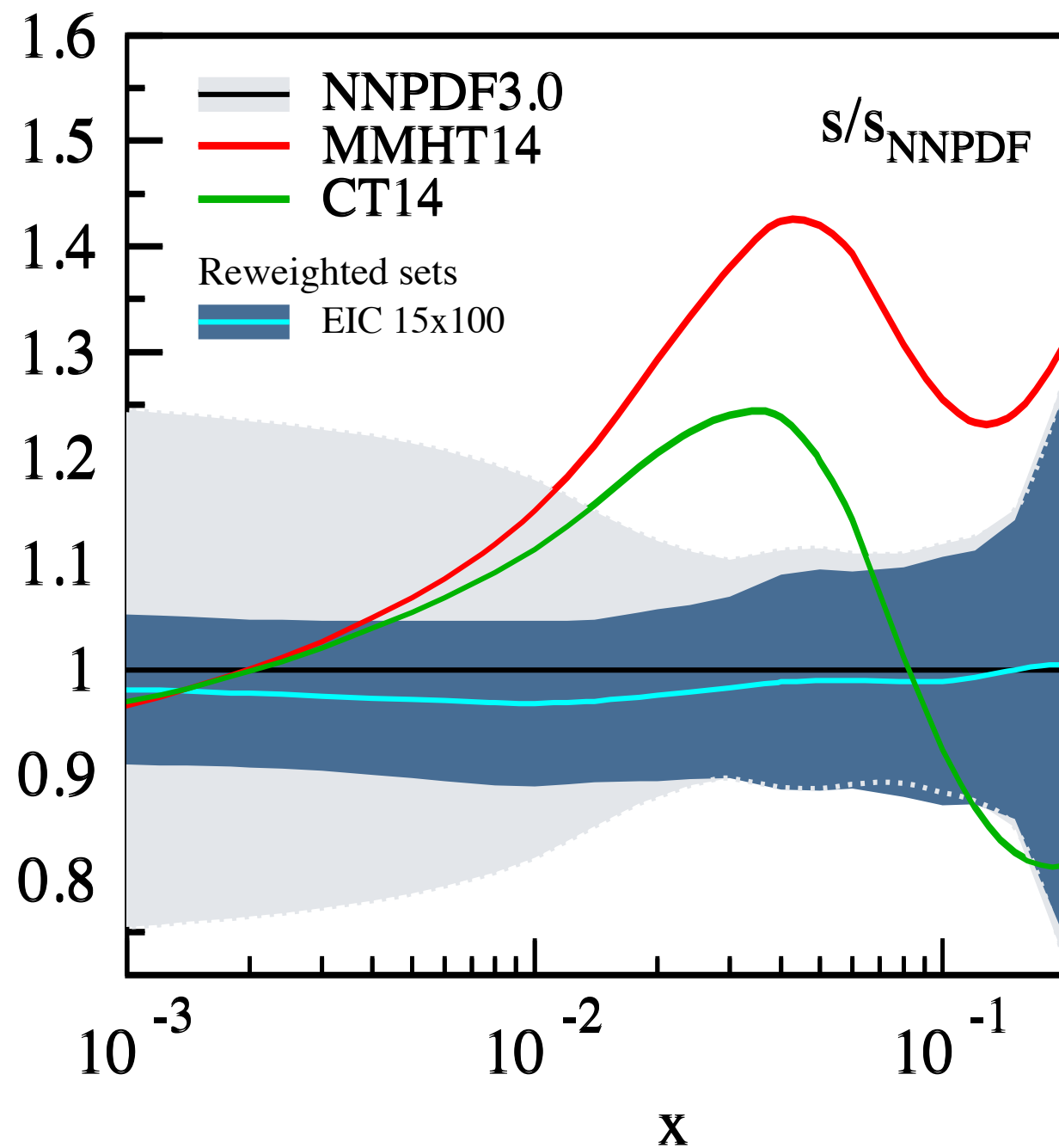


precision tool for:

strangeness in the proton
isospin breaking
charge symmetry breaking

flavor without d or A targets

SIDIS at EIC:

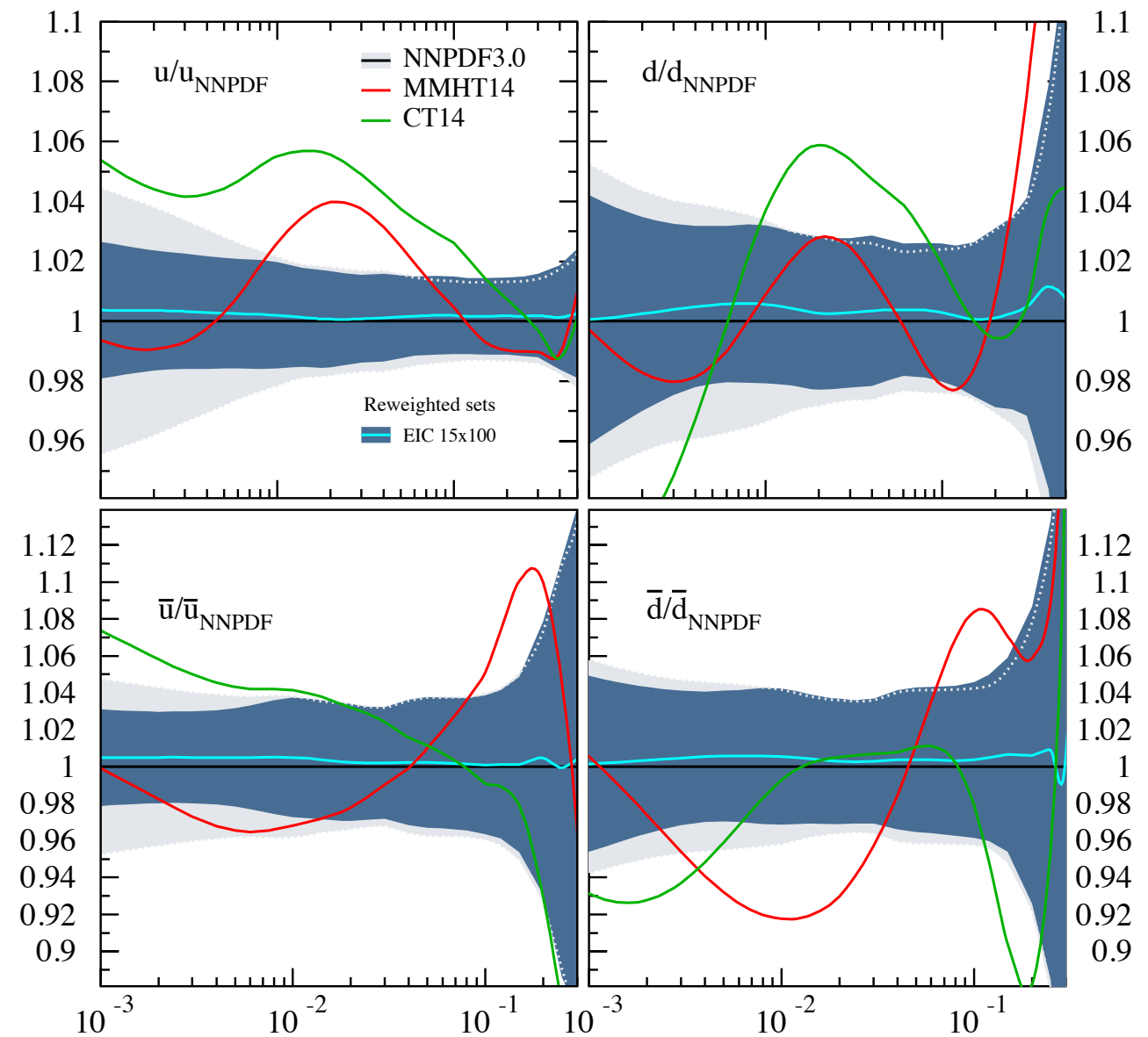
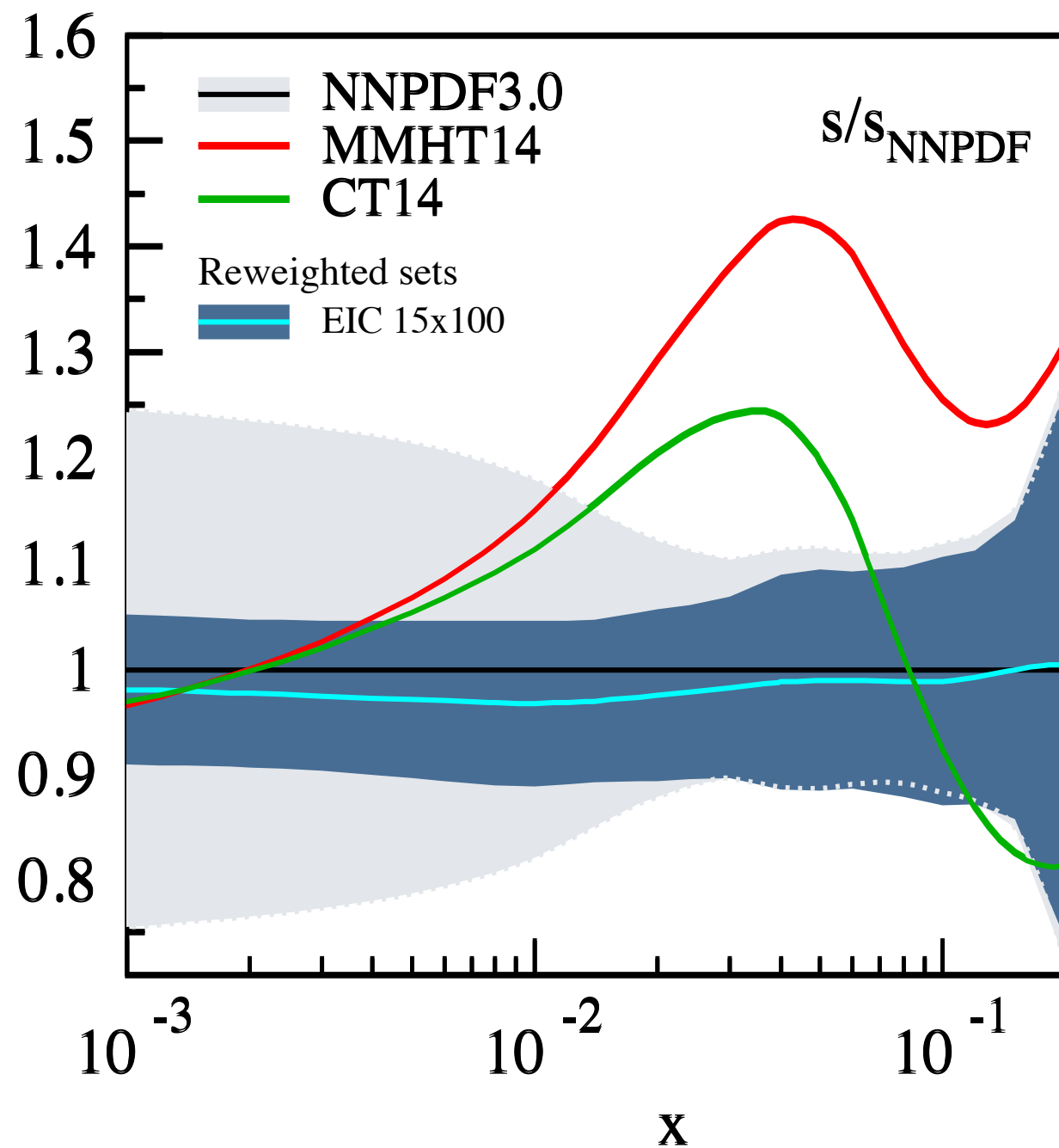


precision tool for:

strangeness in the proton
isospin breaking
charge symmetry breaking

flavor without d or A targets
nuclear effects

SIDIS at EIC:



precision tool for:

strangeness in the proton
isospin breaking
charge symmetry breaking

flavor without d or A targets
nuclear effects for PDFs and FFs

Summary:

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updated DSS set of FFs for kaons: new data (x5), uncertainties, input PDFs

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combined analysis **PDFs & FFs works**

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EIC SIDIS data expected to have a significant **impact** for PDFs & FFs:

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updated DSS set of FFs for kaons: new data (x5), uncertainties, input PDFs

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nuclear effects in initial and final states

experiment	data type	norm. \mathcal{N}_i	# data in fit	χ^2
TPC [39]	incl.	1.003	12	13.4
SLD [35]	incl.	1.014	18	17.2
	<i>uds</i> tag	1.014	10	31.5
	<i>c</i> tag	1.014	10	21.3
	<i>b</i> tag	1.014	10	11.9
ALEPH [32]	incl.	1.026	13	29.7
DELPHI [33]	incl.	1.000	12	6.9
	<i>uds</i> tag	1.000	12	13.1
	<i>b</i> tag	1.000	12	11.0
OPAL [36]	<i>u</i> tag	0.778	5	9.6
	<i>d</i> tag	0.778	5	7.7
	<i>s</i> tag	0.778	5	23.4
	<i>c</i> tag	0.778	5	42.5
	<i>b</i> tag	0.778	5	16.9
BABAR [19]	incl.	1.077	45	30.6
BELLE [20]	incl.	0.996	78	15.6
HERMES [21]	K^+ (p) Q^2	0.843	36	61.9
	K^- (p) Q^2	0.843	36	29.6
	K^+ (p) x	1.135	36	75.8
	K^- (p) x	1.135	36	42.1
	K^+ (d) Q^2	0.845	36	44.7
	K^- (d) Q^2	0.845	36	41.9
	K^+ (d) x	1.095	36	48.9
	K^- (d) x	1.095	36	44.4
COMPASS [24]	K^+ (d)	0.996	309	285.8
	K^- (d)	0.996	309	265.1
STAR [26]	$K^+, K^- / K^+$	1.088	16	7.6
ALICE [25] 2.76 TeV	K/π	0.985	15	21.6
TOTAL:			1194	1271.7